Climate Resilient City Action Plan
JAMMU

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Acronyms

Acronym	Description
AFOLU	Agriculture, Forestry and Other Land Use
BUR	Biennial Update Report
CPP	Captive Power Plant
CRCAP	Climate Resilient City Action Plan
CVI	Composite Vulnerability Index
CMIP6	Coupled Model Intercomparison Project-6
CDP	City Development Plan
DDMA	District Disaster Management Authority
DEE&RS	Department of Ecology Environment and Remote Sensing
DDMP	District Disaster Management Plan
EVI	Economic Vulnerability Index
GHG	Green House Gas
GDP	Gross Domestic Product
GCM	General Circulation Model
GWP	Global Warming Potential
J&K	Jammu and Kashmir
JKHUDD	J&K – Housing and Urban Development Department
JKSPDCL	Jammu and Kashmir State Power Development Corporation Limited
JKRTC	Jammu & Kashmir Road Transport Corporation
JKPWDRB	J&K – PWD (R&B) Department
JKRTC	Jammu & Kashmir Road Transport Corporation
IMD	Indian Meteorological Department
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
kt CO_2e	kilotonnes of Carbon dioxide equivalent
NVI	Natural Vulnerability Index
NATCOM	National Communication
PEG:	Public Electricity Generation
PVI	Physical Vulnerability Index
SVI	Social Vulnerability Index
SC	Scheduled Caste
ST	Scheduled Tribes
SSP	Shared Socioeconomic Pathway
SDG	Sustainable Development Goal
UHI	Urban Heat Island
ULB	Urban Local Body
UNDRR	United Nations Office for Disaster Risk Reduction
UT	Union Territory
UNEP	United Nations Environment Programme
WRT	with respect to

EXECUTIVE SUMMARY

Executive Summary

Climate change is one of the most pressing issues facing the world today. The Paris Agreement is an international agreement that aims to limit global warming to well below 2, preferably to 1.5 degrees Celsius, compared to pre-industrial levels. India is a signatory to the Paris Agreement and has committed to reducing its greenhouse gas emissions by 33-35% below 2005 levels by 2030. India began by establishing eight national missions to combat climate change in 2008, and it has since regularly altered its own goal to quicken the delivery of Climate Justice. In response to the climate emergency, UNDP India has secured funding from the Japan Supplementary Budget (JSB) 2021 to leverage Nationally Determined Contributions (NDCs) to achieve net-zero emissions and climate-resilient development.

Climate Resilient City Action Planning for Jammu

Coordinates : 32.725820 N, 74.857394 E
Population: 6,91,636 (census 2021)
Area: 240 sq.km
Number of wards: 75

The Department of Ecology, Environment and Remote Sensing, Government of Jammu and Kashmir, and the United Nations Development Programme (UNDP) have prepared this Climate Resilient City Action Plan (CRCAP) for Jammu City. The CRCAP aids the local government of Jammu city in estimating greenhouse gas emissions, identifying vulnerability hotspots, understanding critical infrastructure systems with respect to resilience, and developing specific climate change mitigation and adaptation plans while promoting sustainable development. The CRCAP for Jammu typically includes a thorough analysis of climate change risks, and GHG emissions, identifying priority areas for action, and developing action plans that include specific measures to boost the resilience and adaptive capacity of Jammu city.

Climate of Jammu

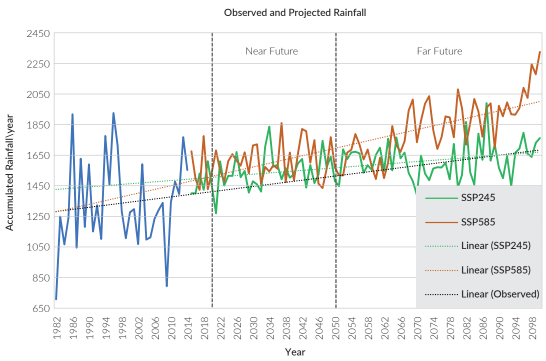
Jammu city's future climate under SSP-245 scenario suggests the accumulated rainfall is projected to increase by 137 mm/yr in near future and by 208 mm/yr in far future. In SSP-585 scenario the accumulated rainfall is projected to increase by 209 mm/yr and 516 mm/yr in near and far future respectively. Under SSP-245 scenario in near future the maximum and minimum temperature is projected to increase by 0.97°C and 1.41°C respectively. In far future, under SSP-245 scenario the maximum and minimum temperature is going to increase by 2.21°C and 1.99°C respectively. Under SSP-585 scenario in near-future the maximum and minimum temperature are projected to increase by 1.10°C and 1.61°C respectively while as the upsurge is on higher end by 3.97°C and 4.62° C in far-future.

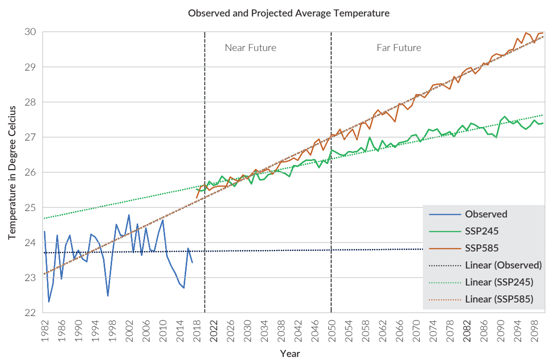
Table 1 Annual Accumulated Rainfall w.r.t to baseline period (1976-2005)

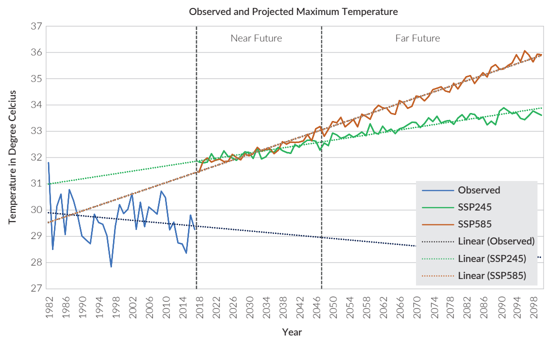
Change in R (mm) SSP 245 2020-2050	Change in R (mm) SSP245 2051-2100	Change in R (mm) SSP585 2020-2050	Change R (mm) SSP585 2051-2100
↑ 137 mm/year	↑ 208 mm/year	↑ 209 mm/year	↑ 516 mm/year

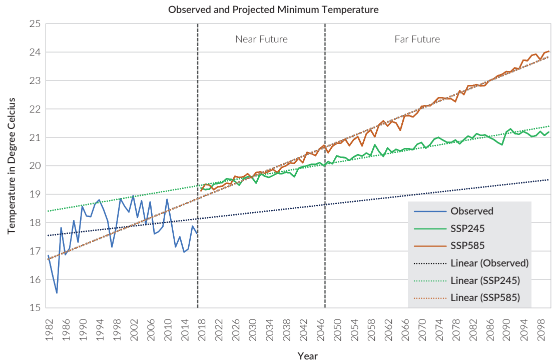
Table 2 Maximum Temperature Changes w.r.t to baseline period (1976-2005)

Parameter	Region	SSP 245 2020-2050	SSP245 2051-2100	SSP585 2020-2050	SSP585 2051-2100
Change in Max T (°C)	Jammu Station	↑ 0.97°C	↑ 2.21°C	↑ 1.10°C	↑ 3.79°C
Change in Min T (°C)		↑ 1.41°C	↑ 1.99°C	↑ 1.61°C	↑ 4.62°C



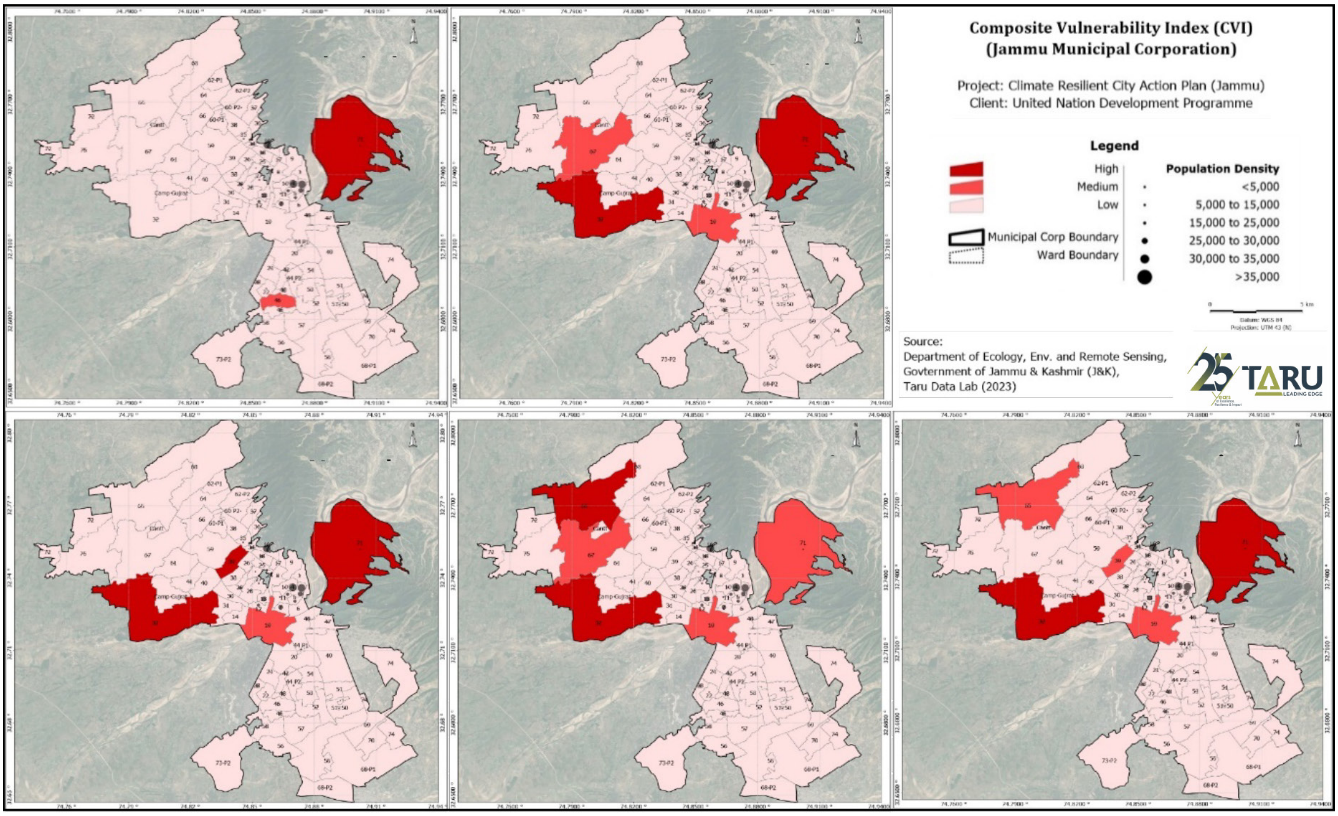






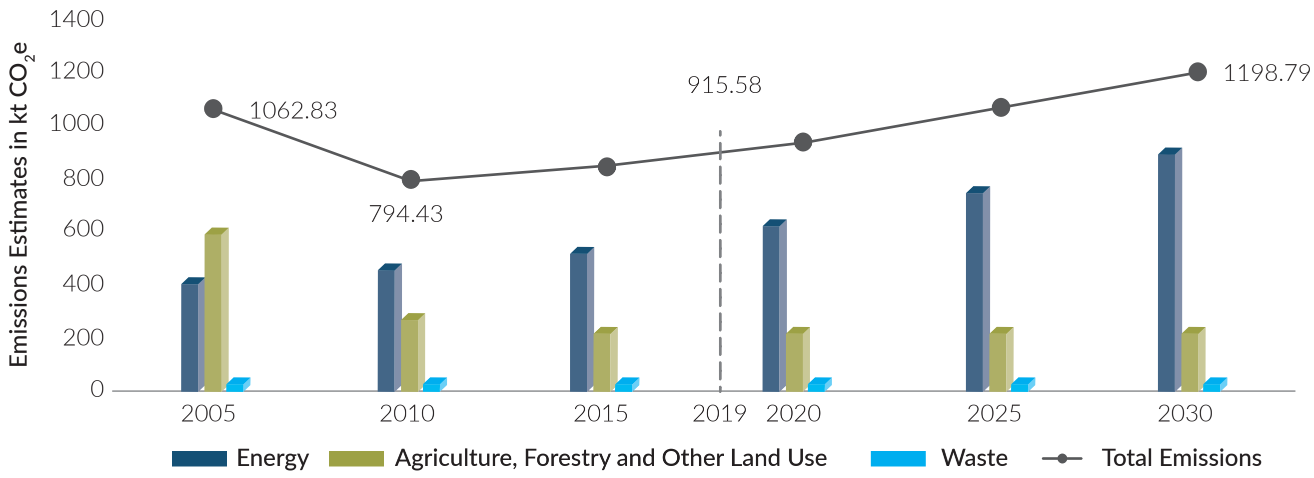
Vulnerability Assessment

Vulnerability assessment is conducted in two levels namely – City level and Ward level. City-level vulnerability assessment is based on understanding the climate-induced risk of various hazards and their exposure to critical urban services and populations spatially. The ward-level vulnerability assessment uses four dimensions (Natural, Social, Economic and Physical Vulnerability). Decision-makers need to understand the most vulnerable wards to focus on those wards towards improving services to make them more adaptive and resilient.



GHG emissions

Jammu city's GHG emissions declined from 1062.83 kilotonnes of CO_2 equivalent (kt CO_2e) in 2005 to 915.58 kt CO_2e in 2019, at a CAGR of 1%. Despite a steady rise in energy emissions, the overall economy-wide emissions declined as a result of the significant decrease in emissions from the AFOLU sector (due to livestock emissions). Emissions from the Waste sector marginally increased during the reference period from 39.81 kt CO_2e in 2005 to 55.29 kt CO_2e in 2019. Under the BAU scenario, the emissions are expected to increase almost 1.3 times or ~31% from 2019 level (915.58 kt CO_2e). As per the projections, energy sector will be the key driver of emissions in the city, accounting for ~77% of the total GHG emissions in 2030.



Climate Resilient City Action Plan for Jammu city

Sectors	Key Interventions	Mitigation Potential	Overall Climate Resilience Impact
Power, Energy and Habitat	• Scale up Renewable Energy (RE) installation	113,502 t CO_2e /yr from households alone	Reduction of GHG emissions, Improved awareness among citizens regarding uptake of RE
	• Replacing Diesel Gensets in residential/ commercial/ institutional sectors with solar-powered or other RE + storage options.	1.34 t CO_2e /yr for each generator replaced.	
	• Encourage faster penetration of the Street Lighting National Programme (SLNP) and UJALA Scheme (Domestic Efficient Lighting Program).	LED bulb: 0.15 t CO_2 /bulb/yr LED tubelight: 0.036 t CO_2/tubelight/yr Fan: 0.076 tCO_2/fan/yr	
	• Adoption of Energy Conservation and Sustainable Building Code (ECSBC) and Indian Green Building Council (IGBC) standards	Save 254 kg CO_2e per annum per household (Scenario: a household that consumes 6 cylinders of LPG in a year, shifts to cooking through electricity)	
Sustainable Transport	• Promote wide-scale adoption of Electric Vehicles (EV)	Replacing 30% of registered cars in Jammu city can avoid 3160 t CO_2e /year. For an average run of 22 km per day, 2100 kg CO_2 /year per bus can be avoided by switching to electric buses	Reduction of GHG emissions, improved air quality, reduced traffic congestion and improved public health
	• Replacing 30% of registered cars in Jammu city	Can be assessed by obtaining the current energy demand for all PT and IPT infrastructure of the city.	
	• Strengthening public transport (PT) and intermediate public transport (IPT) in Jammu city	Shift from private to public transport can save emissions by 30-40% from the transport sector. Accurate mitigation potential requires passenger km travelled, current modal share and target modal share developed according to city needs.	
	• To increase the share of non-motorized transport in Jammu city	Can be estimated from a reduction in trips made by vehicles for short-distance travel	
Agriculture and Green Spaces	• Enhancing green cover by increasing trees outside forests and green spaces.	Setting a target of increasing the area under forest and trees in Jammu city from 7% (11.9 km2) to 10% (17 km^2) i.e. 3% increase by 2030, will contribute to sequestration of 45,342 t CO_2e per year.	Curb GHG emissions and maximizes sequestration. Provides much needed shade to reduce energy demand for cooling of buildings
	• Promote Sustainable and Zero Budget Natural Farming	Replacing 10% of the current use of chemical fertilizers with organic fertilizers can avoid 475 t CO_2e per annum.	
Waste	• Minimize landfill waste disposal	Extensive amounts of primary data and various fractions (like % of recyclable waste, and waste composition) are required to estimate the mitigation potential.	Highest potential to reduce GHG emissions. improved public health and safety. PPP models will lower the financial impact on ULB
	• Establish composting facilities	If 100% compostable waste is composted, Jammu City can avoid 4,617 t CO_2e per annum.	

INTRODUCTION

VISION:

Towards a Net Zero & Climate Resilient Jammu

Jammu city is home to over 0.69 million people and thrives on a diverse economy due to its rich heritage, cultural heritage, scenic beauty and tourist influx. Tourists visit Jammu city to see its historic temples, palaces, and museums and explore the nearby hill stations and pilgrimage sites. Although, the city is increasingly at risk due to temperature rise which is projected to increase by 1.5°C and rise in precipitation.

These increasing temperatures, depleting natural green cover, and frequent bouts of extreme rainfall resulting in severe waterlogging conditions incur severe losses to the city's economy and people. A high proportion of the naturally occurring ecosystems of the city are facing constant interferences and inclusions by being replaced by the coming up of newly built-up areas, in light of the increasing urbanization, seasonal migration and natural increase in the population. Also, the remnant parts are facing constant threats in the form of anthropogenic activities In this context, DEE&RS has led the process of drafting the first-ever, Jammu Climate Resilient City Action Plan (CRCAP).

The CRCAP- Jammu envisions a city where its communities and citizens are safer, healthier, and thrive even in a changing and uncertain climate. The CRCAP is committed to a net zero and climate-resilient Jammu by 2050. This means ensuring just transitions – towards net zero pathways; significant investments– towards inclusive and transformative climate solutions; and coordinated and robust governance – to ensure a targets-based approach. We acknowledge that the climate crisis is already affecting us all, although in varying ways, and the time for action is now to secure a better future for all by 2050.

Mindful of the consequences of climate change to future generations living in Jammu and its region, the CRCAP recognizes that actions must be prioritised across four sectors – power, energy and habitat sector; sustainable transport; agriculture and green spaces; waste management. The actions identified in each sector area are framed on four pillars of success (Figure 1).

Tourism-centric Economy	Engagement	Environment	Inclusivity and Equity
Economic activity catering to tourism influx to serve to generate a better economy, while being sustainable and triggering more local employment opportunities.	Key stakeholders will include the citizens across vulnerable wards and prominent decision-makers. Herein the citizens engage in climate action planning and the effective implementation of climate actions envisaged and give their valuable inputs.	Stakeholders will take steps to reduce the vulnerability witnessed across the city while building natural assets and maintaining resources for future generations.	Equitable distribution of resources that would lead to improved health and address the needs of vulnerable groups across wards.

Figure 1: Four pillars on which actions and strategies are prepared

Need for Climate Resilient City Action Plan (CRCAP)– Jammu

The initiative to develop CRCAP's in India started in 2009 as a part of the National Action Plan on Climate Change (NAPCC). The Government of India launched the NAPCC to address climate change issues in various sectors such as agriculture, forestry, and energy. Under the NAPCC, the Ministry of Environment, Forest, and Climate Change (MoEFCC) developed guidelines for preparing CRCAP's in urban areas. The guidelines provide a framework for cities to identify vulnerabilities and develop adaptation strategies to build climate resilience.

Adopting the Paris Agreement on Climate Change at the 2015 Conference of the Parties (COP) of the United Nations Framework Convention on Climate Change (UNFCCC) and its subsequent acceptance by nearly 200 countries marked a significant milestone in climate action.

Climate change is already affecting poor and vulnerable people disproportionately. Climate action is thus not only an environmental issue but also a social justice imperative linked to poverty eradication and increased inclusivity. Adopted in 2015, the United Nations' 17 interconnected Sustainable Development Goals (SDGs) provide a holistic framework and vision for the world to address these issues. Each of these goals is closely linked to climate action mandated by SDG 13.

Jammu city is vulnerable to climate change impacts such as floods, landslides, water logging, and water scarcity. These impacts have serious consequences for the city and its residents, including infrastructure damage, threats to public health, and economic disruption that highlight the critical need for a CRCAP. Although the city does not have a comprehensive climate action plan, some initiatives have been undertaken to address environmental issues, such as waste segregation and composting, plantation drives, air and water pollution monitoring, and renewable energy. It is important to note that while these initiatives are steps in the right direction, they do not constitute a comprehensive climate action plan needed to assess and address the challenges posed by climate change in the city in the context of urbanization and vulnerability. Hence, it is imperative to identify actions to address existing and forecasted climate fragility and develop an implementation and monitoring plan, which will help the city adapt to existing and impending climate change impacts and steer the city's focus to climate change mitigation measures.

The Department of Ecology, Environment and Remote Sensing, Government of Jammu and Kashmir, in association with the United Nations Development Programme (UNDP) have prepared this Climate Resilient City Action Plan (CRCAP) for Jammu City in collaboration with Taru Leading Edge Pvt. Ltd. and Vasudha Foundation. The CRCAP aids the local government of Jammu city in estimating greenhouse gas emissions, identifying vulnerability hotspots, understanding critical infrastructure systems with respect to resilience, and developing specific climate change mitigation and adaptation plans while promoting sustainable development. The CRCAP for Jammu typically includes a thorough analysis of climate change risks, identifying priority areas for action, and developing action plans that include specific measures to boost the resilience and adaptive capacity of Jammu city.

Roadmap to prepare Climate Action Plan – Jammu

To get the initiative started, the first round of kick-off meeting on 7th November 2022 was chaired by Mr. S. Rakesh Kumar (IFS), Director, DEE&RS, Government of J&K. Stakeholders, who would be involved in the development and implementation of the action plan, such as the line departments critical for data collection, were identified. The objectives and scope of the assignment were defined and followed up by an inception report and presentation. Subsequently, all essential data were collected to understand the city and its vulnerabilities. This step was supported by a stakeholder consultation workshop, as a part of which several team members/ consultants visited the city, and the ideation helped in bringing together all the stakeholders. This stakeholder consultation was held on 18th January 2023 at the Jammu Convention Centre.

"the city faces issues due to heavy rainfall a few times a year because of flooding that is witnessed across the city, be it the old city or Gandhi –Nagar area. In the old city a lot of drains have been covered, leaving no way for the storm water to escape.

Jammu Smart City Representative

Figure 2: Photograph of Stakeholder Consultation Workshop - Jammu

During the workshop (Figure 2), discussions were held with the stakeholder departments to assess the current status of service delivery and validate data sets for vulnerability assessment, including ward-level data and GHG emissions inventory of the city to generate a carbon inventory. Also, the plan's financial- and policy-level implications were deliberated upon. The impact of different mitigation and adaptation interventions were also discussed with the stakeholders. To better understand Jammu city and assess its vulnerabilities, a digital questionnaire was filled up by almost 50 participants who were in attendance at the workshop, giving us much-needed insights on the issues witnessed in the city.

This consultation was an essential part of the development of CRCAP in Jammu. It helped to identify key vulnerabilities, understand the needs and concerns of different stakeholders, and develop a shared vision for building climate resilience in Jammu city.

An agenda was developed for conducting the consultation, which included determining the objectives, scope, and timing of the consultation. The aim was to gather information on the stakeholders' needs, priorities, and concerns related to climate change in Jammu and building resilience in the city.

The consultation was designed to encourage active participation, while it ensured that diverse perspectives are represented. The information gathered during the consultation was analysed to identify common themes, priorities, and recommendations. This information was used to inform the development of the CRCAP in Jammu city.

"the degree of waterlogging witnessed across the old city is due to the encroachments, that in turn block the storm water drains.

JMC Representative"

Structure of the CRCAP Document

To better understand the dynamics of the city, a description of the existing climate change hazards, vulnerabilities, and dangers to Jammu city's communities, infrastructure, and economy has been prepared in this document. The CRCAP seeks to provide a statement of the city's desired future state, outlining the key goals and objectives of the action plan. An analysis of the city's exposure to climate change impacts, such as flooding, heatwaves, water logging, and an assessment of the risks to the city's population, infrastructure, and economy is undertaken. The process adopted for climate resilient city action planning and way forward is given in Figure 3.

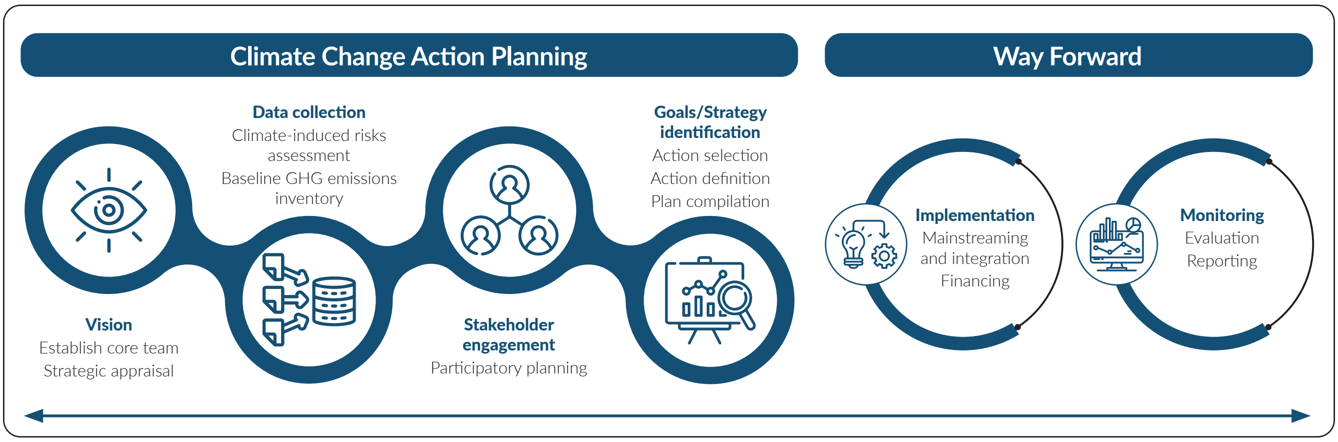


Figure 3: Process adopted for climate resilient city action planning and way forward

Chapter-wise priority actions have been devised as follows, where Chapter 1 gives a glimpse of Jammu city, its connectivity and its landscape. The baseline evaluation of the city is covered in Chapter 2, along with information on climate change, a timeline of previous catastrophes, and the effects of disasters. Chapter 3 discusses climate risks and vulnerability assessment at city and ward levels, focusing on critical assets exposed to hazards. Chapter 4 states GHG baseline inventory. Chapter 5 gives the sectoral action plan with priority (short-term) and medium–long-term plans envisaged to make Jammu city carbon-neutral and climate resilient. The concluding chapters 6 and 7, propose a way forward for the city's future and draw implications from the CRCAP.

CHAPTER

1

CITY CONTEXT

Jammu is a city located in the northernmost union territory of India, Jammu and Kashmir (J&K). The city lies at an average elevation of about 327m above the mean sea level, between 32° 44' 9 North latitude and 74° 52' 9 East longitude. The city is about 600 km north of Delhi and 300 km south of Srinagar, situated on the banks of River Tawi surrounded by the Shivalik mountain range to the north, east, and southeast and the Pir Panjal range to the northwest. Ward no. 37 has the highest average elevation of more than 425 m (as shown in Table 3 and Figure 4). Higher the elevation will have high vulnerability to landslides. The area abutting the highway in this ward 71 is characterized by loose silt and soil, making it prone to landslides and accidents.

Table 3: Average elevation in various wards in Jammu

Average DEM (Height (m))	Wards
<325	12, 14, 19, 20 to 23, 28 to 33, 40 to 46, 52 to 59, 61, 65,67, 68, 72, 73, 75
325-375	1,3,5,6,7,8,10,11,13,15,24,25,26,27,35,39,48,49,50,51,64,66,69,70,71
375-425	2,4,9,16,17,18,34,36,47,60,62,63,74
425-475	37

Jammu city (also known as the 'City of Temples') has a rich cultural heritage and a number of temples which are visited by citizens and tourists every year. More than 10 million tourists visit every year majorly to visit the Mata Vaishno Devi shrine and Amarnath caves.

Jammu is the 79th most populous city in India and the 2nd in J&K. The city population is estimated to increase by 0.9 million in the year 2031 and will grow 1.6 times by the year 2051, having a projected population of about 1.3 million. Additionally, Jammu city has attained the primate city status, accounting for approximately 64% of the region's total urban population in 2011 (JKHUDD, 2022). An overview of the city demographics is shown in Table 4.

Table 4: Overview of Demographics of Jammu City

Specifics	Year 2011 (Census, 2011)	Year 2021 (ICLEI, 2022)
Total Number of Administrative Zones	3	3
Total Number of Administrative Wards	71	75
Total Area	170 sq km	125 sq km[1]
Total Population	5,02,197	6,91,636
Total Males	2,63,141	3,59,862
Total Females	2,39,056	3,31,775
Total Households	1,20,625	1,44,250
Average Household Size (persons per household)	4.91	4.83
Total Slum Population	97,580	97,580
Total Slum Households	17,986	24,094
Total Number of Tourists Per Year	6,00,000 to 8,00,000	10,00,000 to 12,00,000

[1] Data extracted from digital elevation map (figure 4) received from JK-DEE&RS

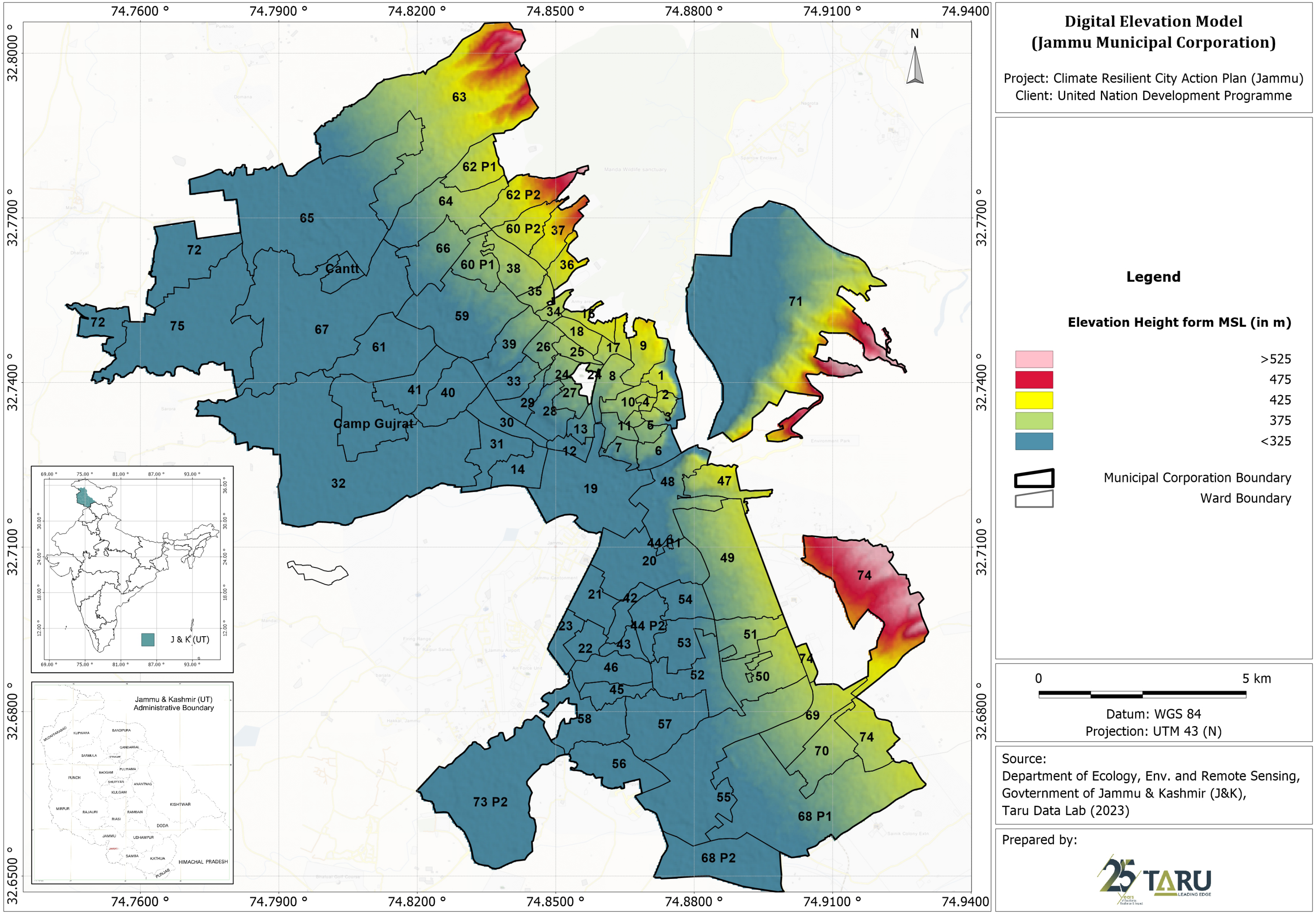


Figure 4: Location and Digital Elevation Model of Jammu City

Connectivity

Jammu city is well-connected to its surrounding areas (as shown in Figure 5). It has prepared a comprehensive mobility plan in the year 2020, which highlights the vision for the city, wherein an attempt to achieve a safe, efficient, reliable, and seamless mobility of people and goods is made, thereby making Jammu a model city.

The total area accounted under the traffic and transport land use was found to be 19.1 sq km for 2011 (JKHUDD, 2022) and the length along all arterial and major roads in the city accounted for 740 km (Comprehensive Mobility Plan, Jammu, 2020).

ROAD NETWORK:
Jammu city is connected to other parts of India through a network of national and state highways. The existing road network of Jammu is basically of radial pattern, which has five major roads, namely, Srinagar Road, Pathankot Road, Akhnoor Road, R.S. Pura Road, and Ambgrota Road (Bantalab Road) that converge in the city from different directions (JKPWDRB, 2020).

RAILWAY:
Jammu city has an important railway station in the northern region of India, and is connected to major cities like Delhi, Mumbai, Kolkata, and Chennai through a network of broad gauge railway lines. Jammu Tawi is the main railway station, which is located in the heart of the city. This railwaystation caters to the maximum number of passengers with 20,681 boarding and 18,938 arriving each day (JKPWDRB, 2020).

AIRPORT:
Jammu city is served by Jammu airport, which is located outside the city municipal boundaries, approximately 8 km (5 mi) from the city centre. The airport is connected to major cities in India like Delhi, Mumbai, Bengaluru, and Chennai through regular domestic flights.

LOCAL TRANSPORT:
Jammu city has a well-developed network of local transport, including buses, taxis, and autorickshaws. Jammu and Kashmir State Road Transport Corporation (JKSRTC) operates regular bus services to other parts of the state and its neighbouring states. Taxis and autorickshaws are available for local transportation within the city. General bus stand is the biggest bus terminal and caters to the maximum number of passengers with 14,443 boarding and 12,624 arriving (JKPWDRB, 2020)each day (JKPWDRB, 2020).

Figure 5: Jammu city connectivity

Land Use Land Cover (LULC)

Land use is not static as it changes from time to time by both anthropogenic factors as well as natural interruptions (Lokinder, Hardev, & Sanjay, 2020). A detailed land use classification for the year 2022 (Jammu city) is represented in figure 7. For the year 2022, the LULC statistics (figure 6) indicate that the majority of the municipal land was covered with core urban (comprising of residential, institutional and commercial built-up) of (39.8%) in the northern and southern part of Tawi river. About 26.67 sq km (21.2%) of the area in the north-western part of the city (wards 32, 67, 72 and 75) and some areas in ward 71 is covered with crop-land. In the north part of city (wards 65 and 63) have 4.42 sq km (3.5%) of Hamlet & Dispersed Household land. The other urban areas and peri-urban areas are in both northern and southern part of the city (wards 55, 59, 62, 65, 68, 71, 73, 74) comprising of 17.11 sq km (13.6%) and 9.35 sq km (7.4%). The closed forest land found in north-eastern part of city (wards 1, 63 and 71) comprises of 4.39 sq km (3.5%). The agriculture plantation / orchards land (in wards 32, 63, 71 and 73) comprises of 2.16 sq km (1.7%).

The canal / drain land found in north part of city (going through wards 29, 30, 40, 59, 61, Cantt area and 65) comprises of 0.22 sq km (0.2%). The dense scrub land is found in eastern part of city (wards 71) comprising of 0.88 sq km (0.7%). The forest plantation land found in north-eastern part of city (wards 1) comprises of 0.92

sq km (0.7%). The industrial area land found in southern part of city (majorly in ward 57 and some part of 46 and 56) comprises of 1.27 sq km (1.01%). The Lakes/ Pond land scattered in the city (some parts of wards 49, 55, 56, 63 and 71) comprises of 0.05 sq km (0.04%). The mixed village settlement land comprises of 1.12 sq km (0.89%). The other rural built-up areas (in some part of wards such as 63 and 65) comprises of 0.38 sq km (0.30%). The river land found near wards 6,7,19,48 and 71 comprises of 1.09 sq km (0.87%). The sandy area- riverine land (near wards 6, 7, 19, 48, 68 and 68) comprises of 2.28 sq km (1.82%). The sparse scrub land found in eastern part of city (wards 71) comprises of 0.65 sq km (0.52%). The stream land found in eastern part of city (wards 71) comprises of 0.87 sq km (0.7%). The transport infrastructure land found in southern part of Tawi river (wards 20, 44 and 49) comprises of 1.79 sq km (1.42%).

Land use and Land cover category	Percentage of land use
Core Urban	39.81%
Crop Land	21.22%
Other Urban Areas	13.62%
Peri-Urban	7.44%
Hamlet & Dispersed Household	3.52%
Closed Forest	3.50%
Sandy area- Riverine	1.82%
Agriculture Plantation/ Orchads	1.72%
Transport Infrastructure	1.42%
Industrial Area	1.01%
Mixed Village Settlement	0.89%
River	0.87%
Forest Plantation	0.73%
Dense scrub land	0.70%
Stream	0.70%
Sparse scrub land	0.52%
Other Rural Built-up Areas	0.30%
Canal/ Drain	0.18%
Lakes/ Pond	0.04%
Barre Rocky	0.01%

Figure 6: Classification of various land uses for Jammu city

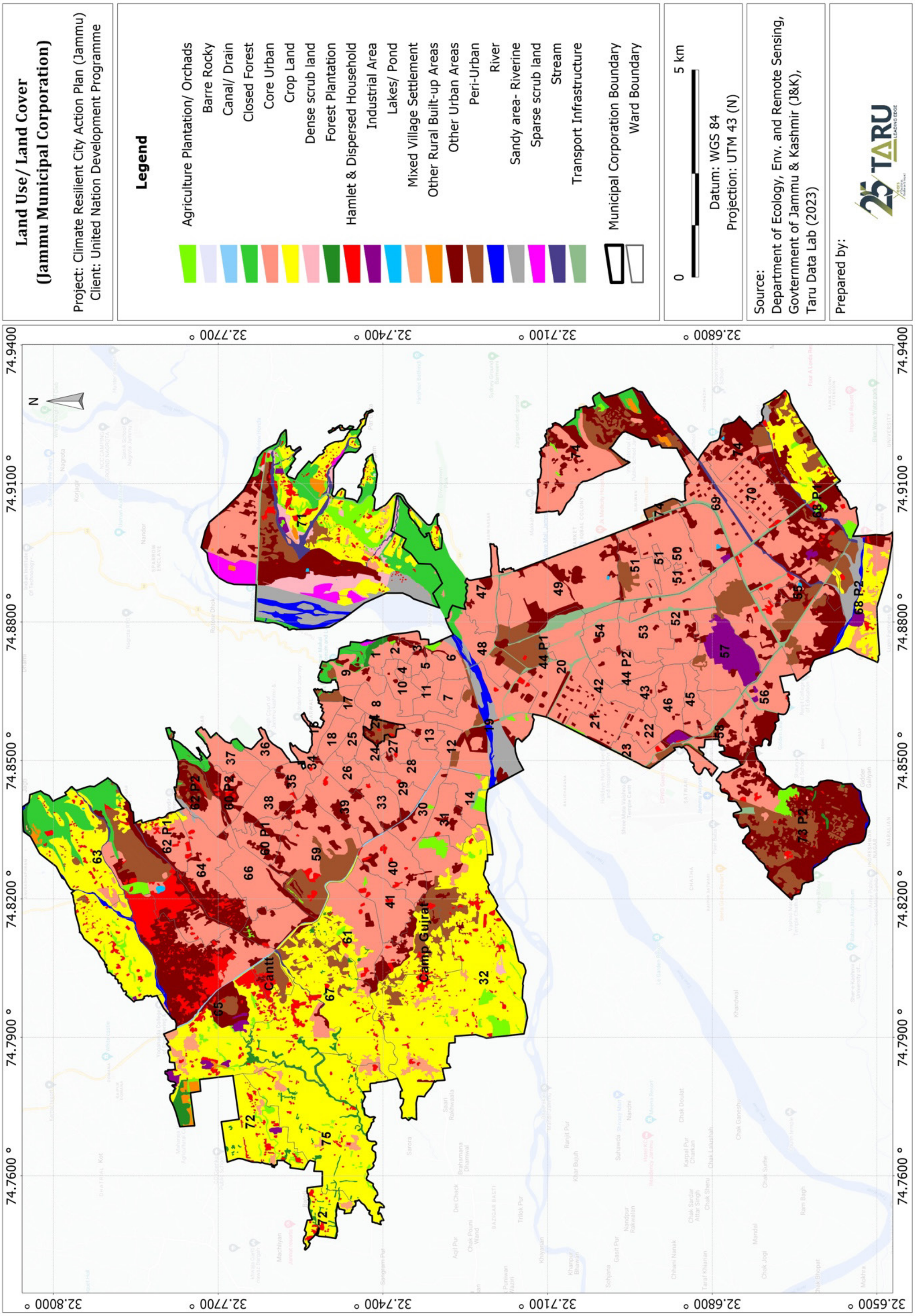


Figure 7: Land Use map of Jammu city for year 2022

Economic Activities

The city had workforce participation of about 34.9% of the total population in 2011. These people were engaged in the service sector, manufacturing and agriculture sectors. Majorly, wards such as 6, 31, 38, and 62 have more workforce participation. In case of Jammu and Kashmir, the tourism sector contributes almost 7.0% to the total Gross State Domestic Product (GSDP) of Jammu and Kashmir and 5.6% to the Gross Domestic Product (GDP) of India, of which a major contribution of J&K state comes from Jammu and Srinagar divisions (Aziz & Bashir, 2022). The city is home to several manufacturing industries, including textiles, electrical appliances, plastics, and rubber products. The city also has a thriving small and medium enterprise sector. Also, Jammu is an important trading centre due to its strategic location on the border with Pakistan and is home to several wholesale markets and trading hubs. As an urban area, Jammu does not have much agricultural activity within its limits. However, it is surrounded by agricultural land and serves as a major market for agricultural produce from the surrounding areas. The major crops grown in the Jammu region include rice, wheat, maize, pulses, vegetables, and fruits. Basmati rice is cultivated in the RS Pura area and then processed in the city's rice mills. The city is also home to several food processing and packaging units. These are just a few examples of the economic activities in Jammu city. The city's economy is diverse and dynamic, driven by various sectors including tourism, agriculture, handicrafts, manufacturing, and trade.

Tourism

Jammu city is a popular tourist destination due to its rich history, cultural heritage, and scenic beauty. Tourists visit the city to see its historic temples, palaces, and museums and explore the nearby hill stations and pilgrimage sites. The tourism industry in Jammu is not limited to traditional leisure tourism. Adventure, pilgrimage, spiritual, and health tourisms are also viable options in the region. According to the Jammu and Kashmir Tourism Department, over 4.5 million tourists visited Jammu and Kashmir in 2019, of which a significant proportion visited Jammu city. Jammu, also known as the city of temples, is in transit and has recently become the main base camp for pilgrims taking the Katra-Vaishno Devi pilgrimage. The city is also a tourist hub for several destinations such as Patnitop, Shiv Khori, Shadara Sharief, Mansar, and Chichi Mata. Throughout the year, tourists from all over the world visit Jammu. The city witnesses the maximum tourist influx in April and October (due to Navratri) and July to August (due to Amarnath Yatra). The tourism infrastructure in Jammu city has been improving over the years, with the development of new hotels, restaurants, and other amenities to cater to tourists.

Biodiversity

The city has a thriving biodiversity, which is rich in both flora and fauna. The flourishing biodiversity is due to the region's co-existence of various naturally occurring ecosystems. So, it is imperative for us to preserve the biological diversity of Jammu. Towards this end, a one-of-its-kind City Biodiversity Index has been formulated for the city of Jammu that would aid the city's administration, stakeholders, and citizens to gain a superior understanding of the city's rare and rich assets, guiding them to strive towards efficient and effective governance strategies, while preserving and conserving Jammu's biodiversity. It is also a moment of great pride to say that Jammu is the ninth city in India to have formulated a City Biodiversity Index. It has been prepared with consistent efforts from the J&K Biodiversity Council, UNDP, and ICLEI-local Governments for Sustainability, South Asia. This index aids in assessing the impacts of land use on the urban biodiversity of the city and would serve as a self-assessment tool, which would be reformulated every five years to keep a tab on its progress.

The city of Jammu is prone to several climate-induced risks, namely, floods, droughts, landslides, forest fires, and windstorms. Also, there is a risk of an increase in greenhouse gas (GHG) emissions, with an increase in city's population, use of vehicles, fuel consumption, etc. The average annual carbon dioxide emissions per person for Jammu and Kashmir (J&K) is 11663.89 Giga gram, which is 0.68% of total India's emissions (1727706.10 Giga gram) (DEE&RS, Govt. of J&K, 2013-14). GHG emissions and climate changes are inevitable and occur mostly due to anthropogenic factors. Reducing emissions and adapting to climate changes are must to make the city more liveable, sustainable, and tourism friendly.

CHAPTER

2

CITY BASELINE ASSESSMENT

2.1. Climate Change

Climate of Jammu

Jammu district has a sub-tropical extreme climate while it is hot and dry in summer and cold in winter. Nights are generally cooler being in the foothills of the mountains. The day and night temperatures start to fall rapidly from November till mid-February. The temperatures start to rise from March to June. The period of December to February is of winter season while March to third week of June is the summer season, followed by southwest monsoon till September. October and November constitute the post monsoon season.

The climate of Jammu is classified as sub-humid to sub-tropical type of climate. June is the hottest month of the year with mean daily temperature ranging between 24.9°C and 41.7°C and reaches up to 47°C. January is the coldest month and temperature comes as low as 4.0°C. The sub humid to sub-tropical city receives normal annual rainfall of 1246 mm. The rainfall in the southwest monsoon season (June to September) is about 69% of annual normal rainfall, while the rainfall in pre-monsoon months (March to May) is about 13% of the annual, July being the month with the highest rainfall with an average of 353.2 mm. During remaining period rainfall is sporadic and scanty. The humidity is lowest in May i.e., 26% and maximum in December and January is 89%. The rainfall is maximum in the months of July and August. Minimum rainfall occurs in November. In the month of January and March the Jammu receives average rainfall of 40-50 mm.

Observed and Projected Climate

The analysis carried out using Indian Meteorological Department (IMD) station data of Jammu from 1982 to 2017 for a period of 35 years for precipitation and maximum & minimum temperature which has been used to calculate the variability and trend in precipitation and temperature respectively.

The WorldClim CMIP-6 Ensemble modelled climate data on precipitation, maximum temperature and minimum temperature was used to derive the future climate projections with respect to baseline of (1976-2005). The projections were analysed for two scenarios SSP-245 (scenario with increased reliance on fossil fuel and no mitigation effort) and SSP-585 (scenario with mitigation efforts). The analysis was divided into two time frames the near-future from 2020 to 2050 and the far-future from 2051 to 2100.

Observed and Projected Rainfall

During the period of analysis, the average annual rainfall observed was 1350.64 mm/yr. The analysis of accumulated rainfall per year from 1982 to 2017 showed an increasing trend with highest accumulated rainfall in year 1986 (1919 mm/yr) and least accumulated rainfall in year 1982 (708 mm/yr) and in year 2009 (794 mm/yr).

The analysis was carried out for accumulated rainfall per year SSP-245 and SSP-585 showed an increasing trend in both scenarios in near as well as far future. Under SSP-245 scenario the accumulated rainfall is projected to increase by 137 mm/yr in near future and by 208 mm/yr in far future. In SSP-585 scenario the accumulated rainfall is projected to increase by 209 mm/yr and 516 mm/yr in near and far future respectively.

Table 5 Annual Accumulated Rainfall w.r.t to baseline period (1976-2005)

Change in R (mm) SSP 245 2020-2050	Change in R (mm) SSP245 2051-2100	Change in R (mm) SSP585 2020-2050	Change R (mm) SSP585 2051-2100
↑ 137 mm/year	↑ 208 mm/year	↑ 209 mm/year	↑ 516 mm/year

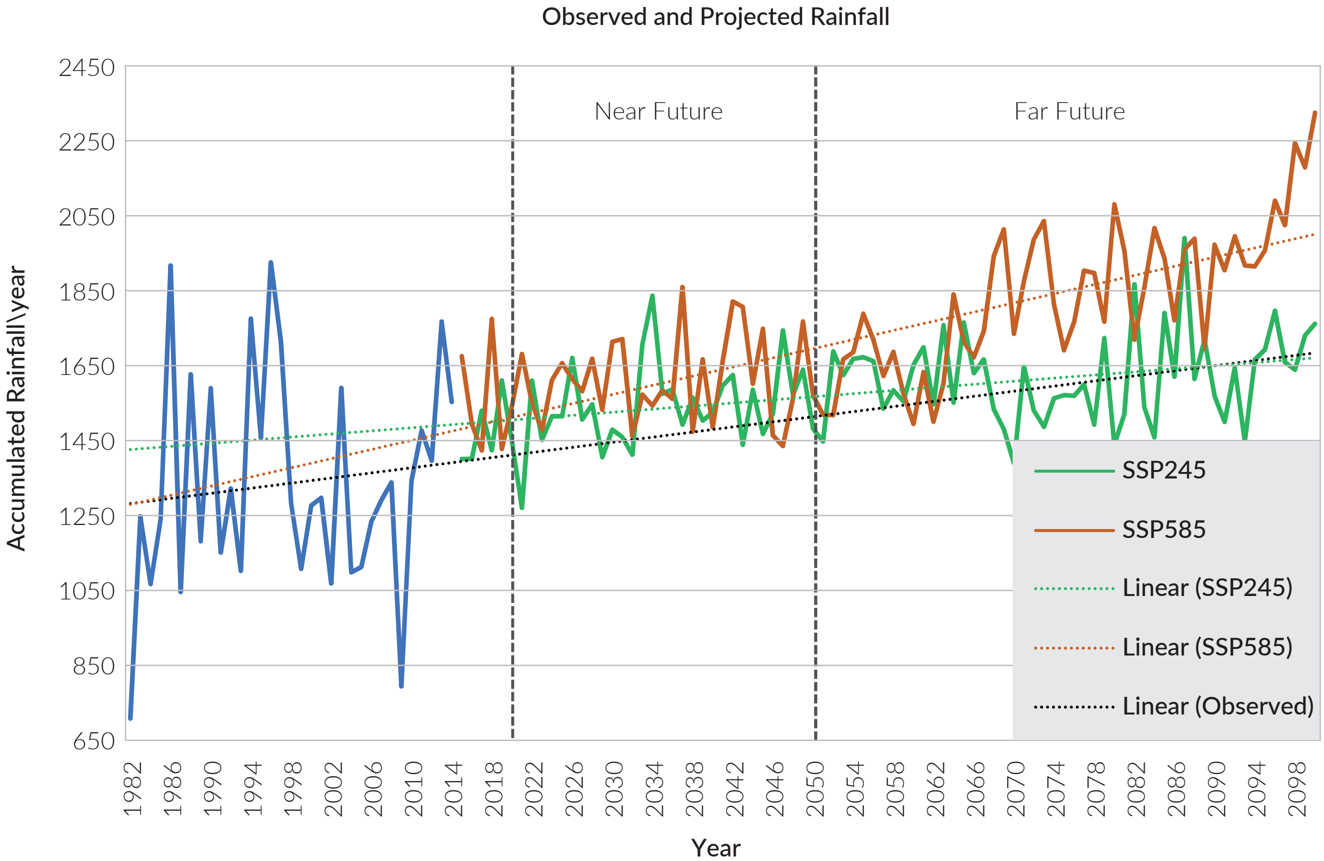


Figure 8: Observed and projected Rainfall

Observed and Projected Temperature

The average maximum temperature observed for the period of 35 years was 29.65°C and the average minimum temperature was 17.83°C. For the period of analysis, the maximum temperature is showing a declining trend while as minimum temperature is showing an increase over the period of time. The annual average temperature is showing a slight increasing trend. In maximum temperature the highest recorded was in year 1982 (31.81°C) and year 2009 (30.72°C). The drop in maximum temperature up to 27.84°C was observed in year 1997 and in year 2015 (28.36°C). In minimum temperature the least recorded was in year 1984 (15.51°C). Recently year 2014 recorded least minimum temperature of 16.95°C.

On annual basis the average temperature showed an increasing trend under SSP-245 and SSP-585 scenarios in near and far future. The maximum as well as minimum temperature is showing a projected increase under SSP-245 and SSP-585 scenarios in near and far-future. Under SSP-245 scenario in near future the maximum and minimum temperature is projected to increase by 0.97°C and 1.41°C respectively. In far future, under SSP-245 scenario the maximum and minimum temperature is going to increase by 2.21°C and 1.99°C respectively. Under SSP-585 scenario in near-future the maximum and minimum temperature are projected to increase by 1.10°C and 1.61°C respectively while as the upsurge is on higher end by 3.97°C and 4.62° C in far-future.

Table 6 Maximum Temperature Changes w.r.t to baseline period (1976-2005)

Parameter	Region	SSP 245 2020-2050	SSP245 2051-2100	SSP585 2020-2050	SSP585 2051-2100
Change in Max T (°C)	Jammu Station	0.97°C	2.21°C	1.10°C	3.79°C
Change in Min T (°C)		1.41°C	1.99°C	1.61°C	4.62°C

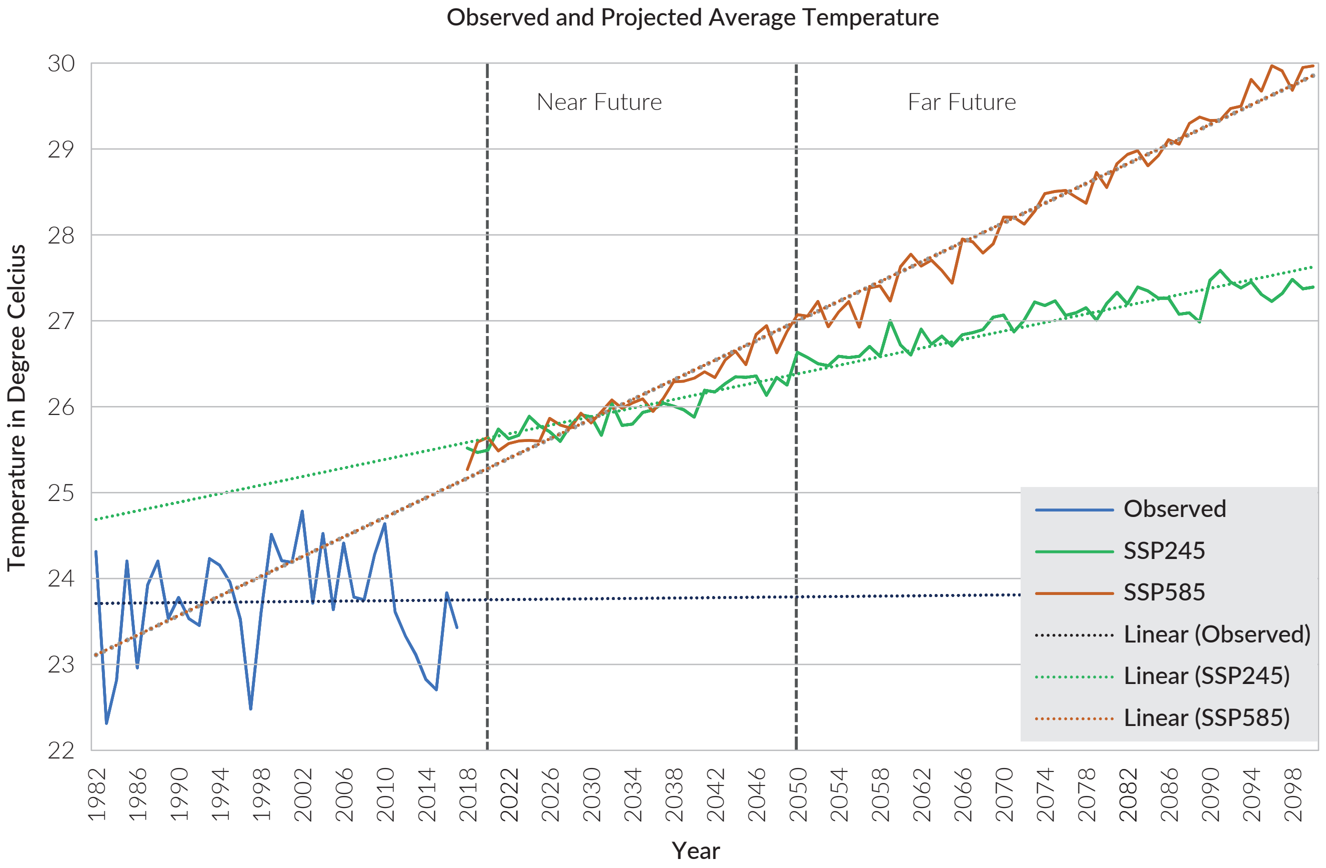


Figure 9: Observed and Projected Average Temperature

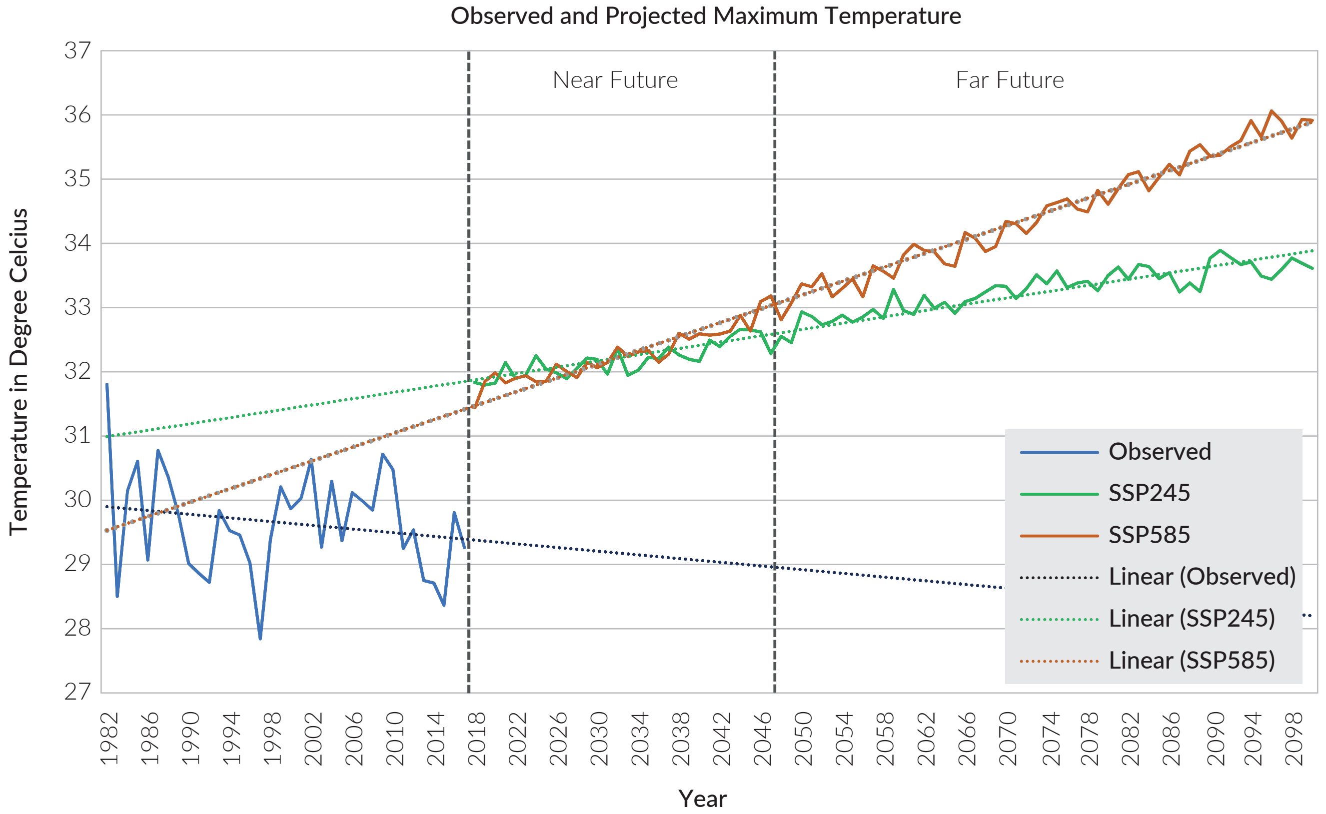


Figure 10: Observed and Projected Maximum Temperature

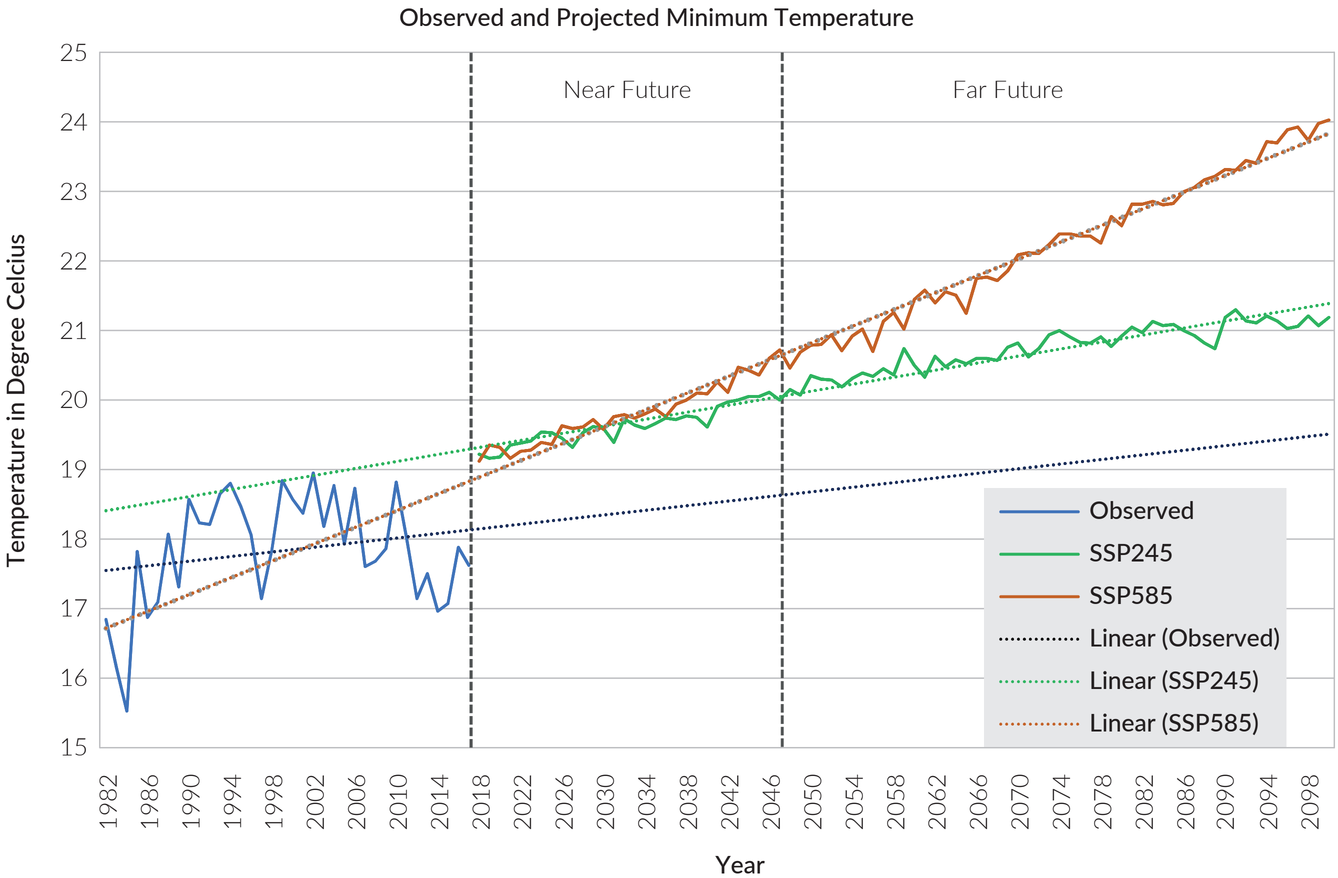


Figure 11: Observed and Projected Minimum Temperature

2.2. Timeline of past disasters

Due to the observed climate changes, it may be noted that several extreme events impacted the city of Jammu in the past and have chance of occurring in the future. The city is prone to various extreme natural disasters (such as earthquakes, floods, and landslides). Timeline of the witnessed disaster events is shown below:

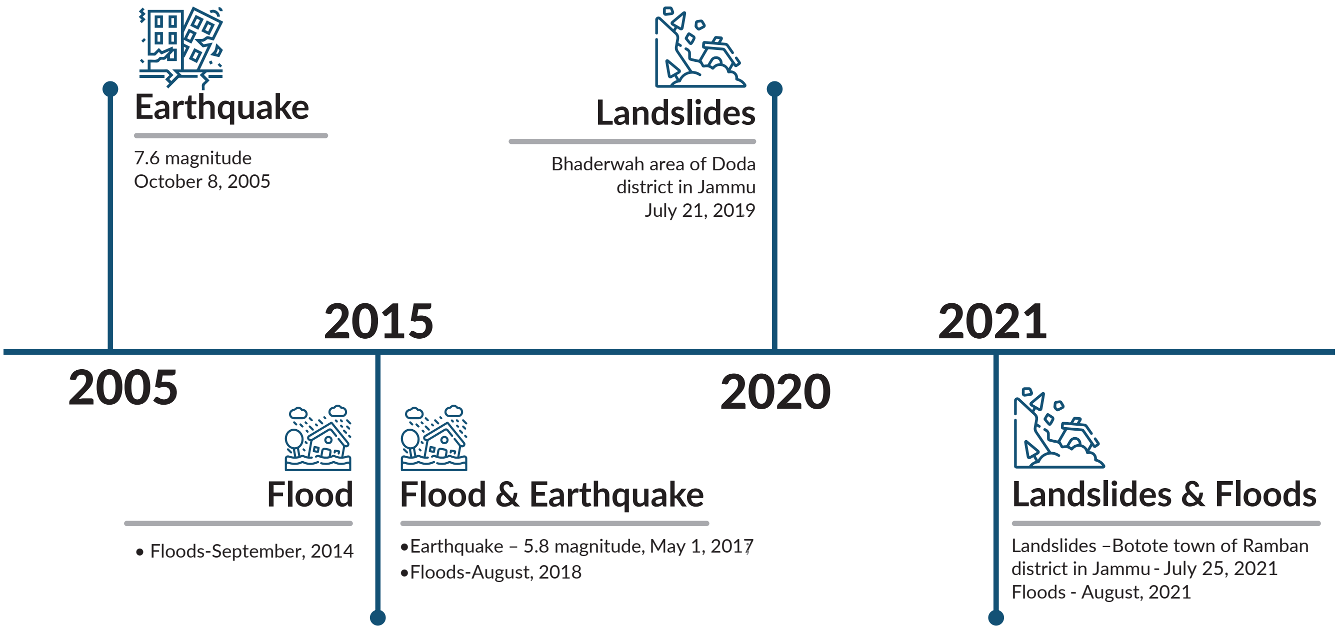


Figure 12: Timeline of Disasters in Jammu Division

2.3. Climate-Induced Impacts on the City

The City of Jammu has been impacted frequently by heavy rainfall leading to waterlogging in several areas (as shown in Figure 13). The impact of other hazards such as landslides, earthquakes, drought and forest fire in Jammu is less observed in the city area. The city's drainage system often cannot handle heavy rainfall, leading to water logging on the streets and low-lying areas. In September 2015, Jammu city experienced severe water logging due to heavy rainfall. The situation was exacerbated by an inadequate drainage system, which could not handle the volume of water.

Figure 13: Water Logging Due to Heavy Rainfall – Jammu City (JK News Today, 2022)

Rainwater entered many localities in Jammu like Kalika Colony, Bahu Fort, Doda Residents Colony, Rajiv Nagar, Nanak Nagar, Preet Nagar, Gangyal, Belicharana, Trikuta Nagar, Gole Market Gandhi Nagar, Talab Tilloo, Shakti Nagar, Canal Road, Qasim Nagar, Lower Gumat and Ban Talab near Petrol Pump (K N Filling Station) and adjoining locality (Cross Town News, 2021). In Dogra Chowk and Bikram Chowk, about one-and-half feet water level was witnessed (Cross Town News, 2021).

There has been frequent occurrence of flash floods (in year 2014, 2018 & 2021) witnessed in Tawi due to high rainfall, especially in the months of July, August, and September, and in the upper catchments of all the tributaries of Tawi, Basanter, Devak, Bhalol, Thathar, and other rivers of Jammu Local Planning Area (LPA 2032). The lower parts of these rivers, which are inhabited, are also in danger of deluge during peak discharge from the monsoon rains, causing damage to roads, houses, infrastructure, and agricultural lands. In light of the same, a Disaster Management Plan for River Tawi was formulated in 2017, considering the high number of flash floods that occurred. The river Tawi has been divided into five zones (A, B, C, D, and E) according to their levels of vulnerability for effective implementation of the plan.

The Jammu Municipal Corporation (JMC) took several measures to address the situation, including dewatering, by deploying water pumps and cleaning drains. The Army and the National Disaster Response Force (NDRF) also assisted in the rescue and relief efforts. JMC maintains the city's drainage system, but its capacity is often overwhelmed during heavy rainfall. The government has undertaken various initiatives to address the water logging problem in Jammu city, including constructing new drains and cleaning the existing ones.

It is important to note that these hazards mentioned are not limited to Jammu city alone but can affect the entire Jammu region and the outskirts of Jammu city. It is essential for residents and tourists to remain informed about potential hazards as early as possible and take appropriate measures to stay safe.

CHAPTER 3

CLIMATE RISK & VULNERABILITY ASSESSMENT

Chapter 3: Climate Risk and Vulnerability Assessment

Vulnerability according to IPCC-AR6 is defined as *"the propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements, including sensitivity or susceptibility to harm and lack of capacity to cope and adapt (IPCC -AR6, 2022)"*. In other words, vulnerability is the inability to resist a hazard or respond to a disaster. For instance, people living on plains are more vulnerable to floods than those living higher-ups. In fact, vulnerability depends on several factors, such as people's age and state of health, local environmental and sanitary conditions, as well as on the quality and state of buildings and their location with respect to any hazards (RMSI, 2014). Families with low incomes often live in high-risk areas in the cities, because they cannot afford to live in safer (and more expensive) places. Similarly, a wooden house is sometimes less likely to collapse in an earthquake, but it may be more vulnerable in the event of a fire or a cyclone (RMSI, 2014).

Jammu city's future climate under SSP-245 scenario suggests the accumulated rainfall is projected to increase by 137 mm/yr in near future and by 208 mm/yr in far future. In SSP-585 scenario the accumulated rainfall is projected to increase by 209 mm/yr and 516 mm/yr in near and far future respectively.

Under SSP-245 scenario in near future the maximum and minimum temperature is projected to increase by 0.97°C and 1.41°C respectively. In far future, under SSP-245 scenario the maximum and minimum temperature is going to increase by 2.21°C and 1.99°C respectively. Under SSP-585 scenario in near-future the maximum and minimum temperature are projected to increase by 1.10°C and 1.61°C respectively while as the upsurge is on higher end by 3.97°C and 4.62° C in far-future. This will result in more pronounce urban and fluvial flooding, heat stress, increase landslides, forest fires and drought.

3.1. Framework of Vulnerability:

Vulnerability assessment is conducted in two levels namely – City level and Ward level. The overarching framework of vulnerability assessment is shown in Figure 14.

1) City-level Vulnerability:

City-level vulnerability assessment is based on understanding spatially the climate-induced risk of various hazards and their exposure to critical urban services and population.

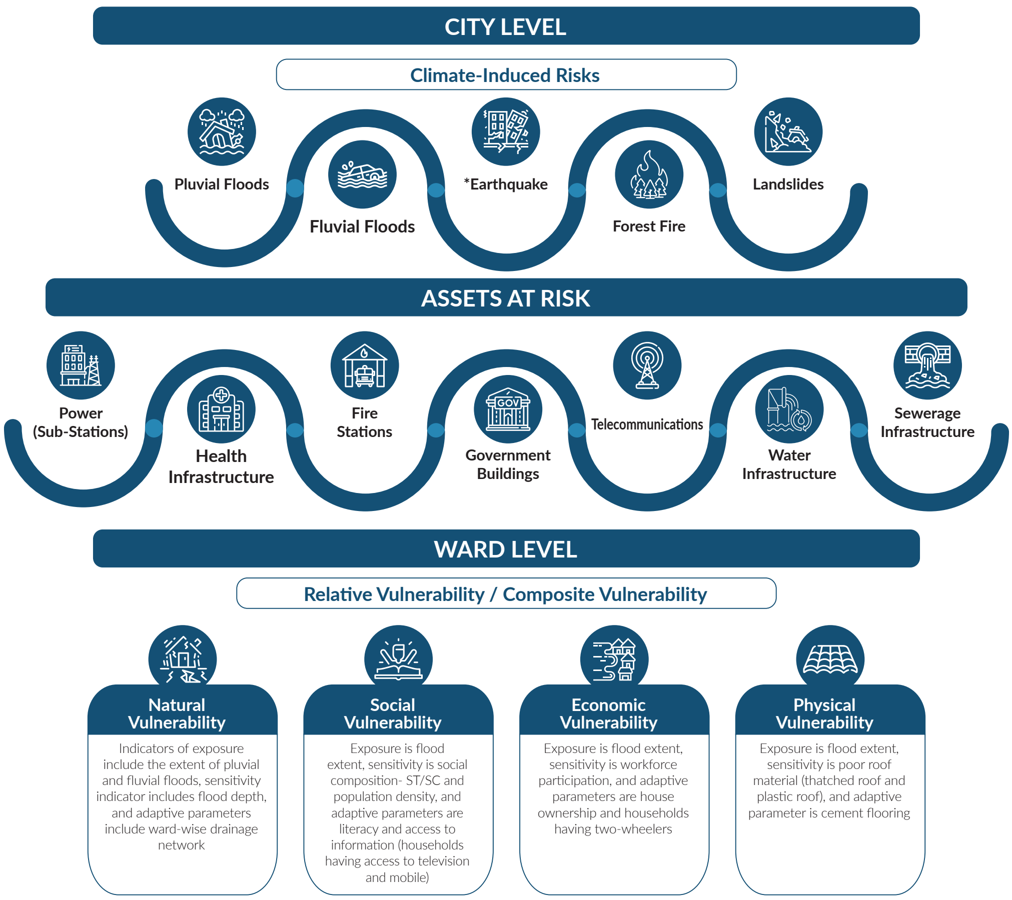


Figure 14: Framework of Vulnerability Assessment

The assessment is conducted using the Tier 1[2] approach, which mainly utilizes secondary data (such as GIS data for various urban services and IMD station data) collected from various departments.

2) Ward level Relative Vulnerability:

Most vulnerable wards are important to understand for decision-makers so that they can focus on those wards towards improving services to make them more adaptive and resilient. The ward-level vulnerability assessment uses four dimensions (Natural, Social, Economic and Physical Vulnerability) (Jha, Negi, Alatalo, & Negi , 2021).

The selection of suitable site-specific indicators is required to address multifaceted issues for vulnerability assessment. Therefore, the indicators (as shown in Figure 15 for the assessment of each dimension are classified into three functions (i.e. sensitivity, exposure and adaptive capacity) and have been selected post careful evaluation (Rationale of selection is as given in Table 7). Post the assessment of four dimensions composite vulnerability index has been calculated to understand the wards which need prior action to resilience. The detailed methodology is given annexure 8.6.

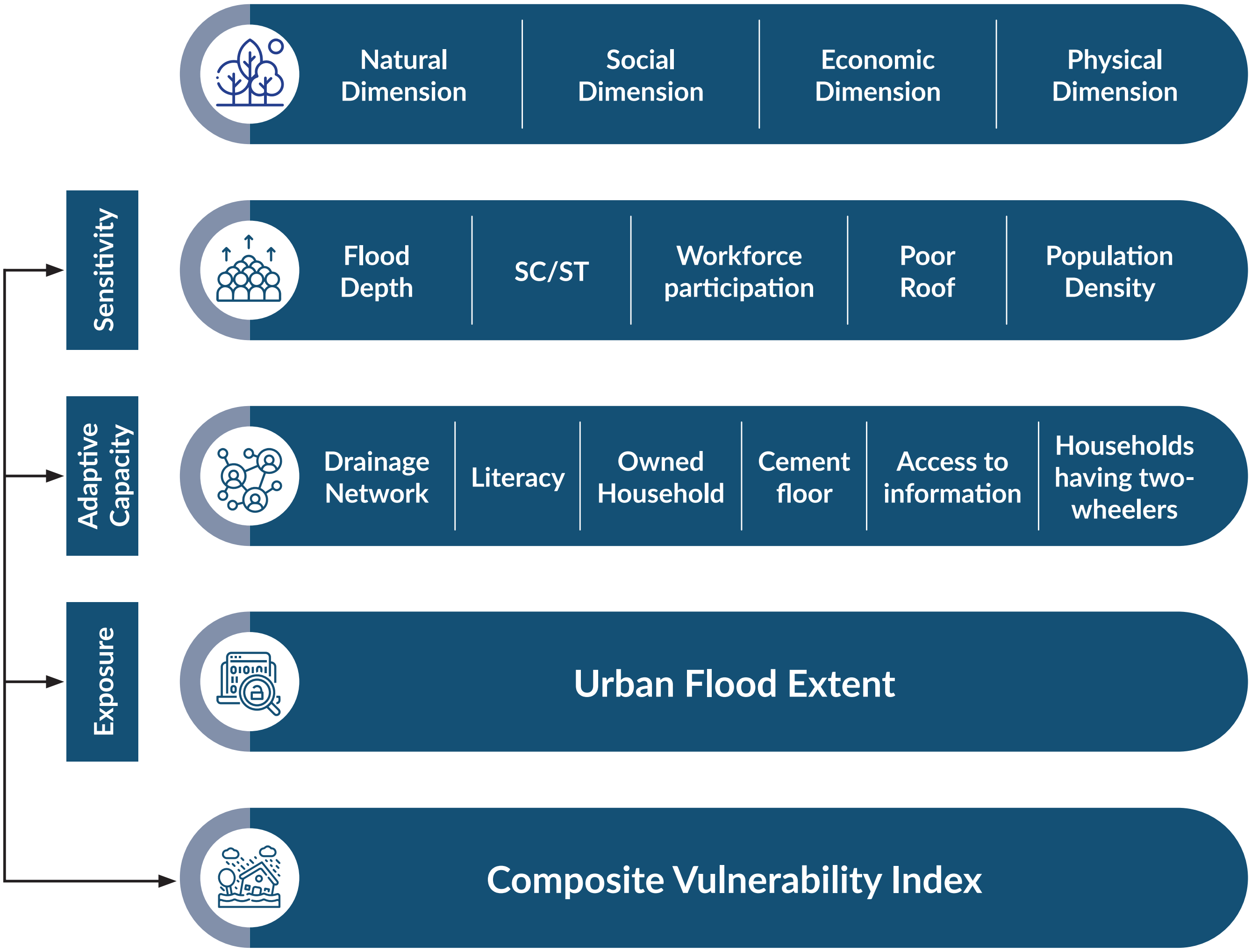


Figure 15: Ward-level vulnerability dimensions and indicators

[2] Source: Climate Vulnerability Assessment for the Indian Himalayan Region Using a Common Framework, IIT Guwahati and IIT Mandi, 2018-19

Table 7: Relative vulnerability indicators and rationale

Dimension	Sub-indicators	Rationale for selection	Functional relation with Vulnerability	Source of data
Natural	Flood depth	Higher the flood depth, higher the vulnerability of assets and population.	Positive	Exposure data received from DEE&RS
	Drainage Network	Household connected to drainage pipelines will be able to drain off flood easily. Hence, vulnerability will be less.	Negative	Data received from Urban Environmental Engineering Department (UEED) - Jammu
Social	Population Density (Total population of a ward divided by the total geographical area)	Population density determines the extent of dependency and per capita availability of finite resources. Higher the density higher is the exposure of community to climatic hazards.	Positive	Calculated using Geographic Area (received from DEE&RS) and population data from Census of India (2011).
	Vulnerable group population- SC/ ST, marginalized groups	The temperature and rainfall changes due to climate change pose a higher risk to the already stagnant or declining population of this group. Further, the population has weaker economic sections hence are more vulnerable.	Positive	Census of India (2011)
	Literacy	Literacy levels contribute directly to the mitigation and adaptive capacity towards the climate induced adversaries. Thereby lower the literacy, higher the sensitivity to the impact. Literacy capacitates the individuals and communities towards informed decision-making, higher awareness and thereby greater coping strength.	Negative	Census of India (2011)
	Access to information	Access to information refers to early warning system. It is critical that people are fully informed about the hazard, its possible impact, and preparedness measures during a catastrophic event. Citizens who are not aware will be negatively impacted by the tragedy, increasing their susceptibility.	Negative	Census of India (2011)
Economic	Main worker / Workforce participation	The availability of work opportunity or means of livelihoods through the year is essential to ensure economic resilience in any crisis situation. The less economically weaker will have greater capacity to response and restore resilience in any disaster situation	Positive	Census of India (2011)
	Land Ownership	Land ownership is a crucial indicator that ensures economic resilience during any disaster situation. It facilitates opportunities for high social and economic capital and thus reduces sensitivity and enhances adaptive capacity	Negative	Census of India (2011)
	House with two-wheelers	Household with two-wheeler are considered middle class and can easily cope with disasters.	Negative	Census of India (2011)
Physical	House roof type	Type of dwelling unit determine exposure to hazards. Roof made of biomass, thatches are more sensitive to cyclone and high intensity rainfall and hence their susceptibility is higher.	Positive	Census of India (2011)
	House floor type	Dwelling with cement floor are less susceptible to natural hazards.	Negative	Census of India (2011)

3.2. City Level Vulnerability

3.2.1. Flood Vulnerability

Jammu is prone to high flooding due to the combined effect of torrential rain and topographical changes induced due to weakly-regulated urbanization. The combined flood scenario for 1 in 100-year return period (Figure 16) is a combination of pluvial and fluvial floods assessment, where 15.55 sq. km. (12.26%) of the municipal area is likely to get impacted by flooding with water depth ranging from 0.27 m to 1.43 m. There are 15 water logging locations identified across the city before creating a combined scenario, and these are mainly at places such as the city's low-lying areas like Bhagwati Nagar, Talab Tillo, Jewel Chowk, Rajinder Nagar, Qasim Nagar, Vinayak Bazar, Dogra Chowk, Kacchi Chawni Gandhi Nagar, Sainik Colony, Green Belt. Due to the steep slopes, the surface runoff quickly finds its way into the nearest drains, through which it is discharged into larger drains and eventually into the Tawi River. By and large, the existing drainage network is the same as the road network. As per the revised CDP of Jammu, 20% of the roads have side drains which cover about 40% of the city area. Also, most parts of the city area are without any drainage system. The problem is further compounded due to choking of drains by garbage disposals in the areas where such facility exists. The increase in population has created tremendous pressure on the city's natural drainage system. Although the old city has a sloping terrain, it experiences flooding during the rainy season due to poor infrastructure services. There is a need for drainage network and drainage pumping stations to be implemented in most water-logged wards such as 20, 46, 56, 61 and 67 to help eradicate the water stagnation in the city.

The flood scenario (1 in 100-year return period) indicates that the entire city of Jammu would experience the effects of floods, with Sidhra area (Ward 71) witnessing the most impact, followed by Chand Nagar (Ward 19), Gujjar Nagar (Ward 6), Greater Kailash (Ward 68) and Bhour Gadigarh (Ward 73). The maximum mean depth of floods is witnessed in Wards 6, 19, and 71, which are close to Tawi river. The average depth of the floods is expected to be witnessed in parts of Sidhra, Chand Nagar, and Gujjar Nagar, ranging over 1 m. Sidra is home to many key spots and critical infrastructure, namely, the golf course, Batra Hospital, Government Degree College and many emerging cafes are also being set up adjacent to the highway and bypass road. Since Sidhra has a predominantly hilly topography with elevation mostly between 300–400 m, so the accumulated water does not stay stagnant. Thus, it decreases the cases of waterlogging, making it less vulnerable to urban floods because of its relatively high elevation, even though it is more exposed. The other most-affected areas, namely Chand Nagar and Gujjar Nagar, have an elevation of 300–325 m (less than that of Sidhra) and a high depth of more than 1 m. The wards are characterized by narrow lanes and congested spaces, having a commercial belt next to the main road. This would further aggravate the problems created by fluvial floods, giving the water hardly any space to escape owing to the poor stormwater management system.

Additionally, Bhagwati Nagar (Ward 14), Talab Tillo (Ward 31), and Gole (Ward 32) are also expected to experience a significant impact. All these wards are parts of the older establishments of the city and are in close proximity to Nehar (a canal built by Raja Hari Singh) to which the water channels are opened during the rice growing season, which may further exacerbate the fluvial flooding situation to a great deal. Apart from this, the entire area is a hub for a number of social infrastructure for students because of institutions like the Science College and S.P.M.R. College of Commerce, with a long commercial strip of stationery shops, Yatri Bhawan, and many other government institutional setups like the Convention Centre. Hence, it comes across as a potentially high-risk area in terms of exposure to social infrastructure.

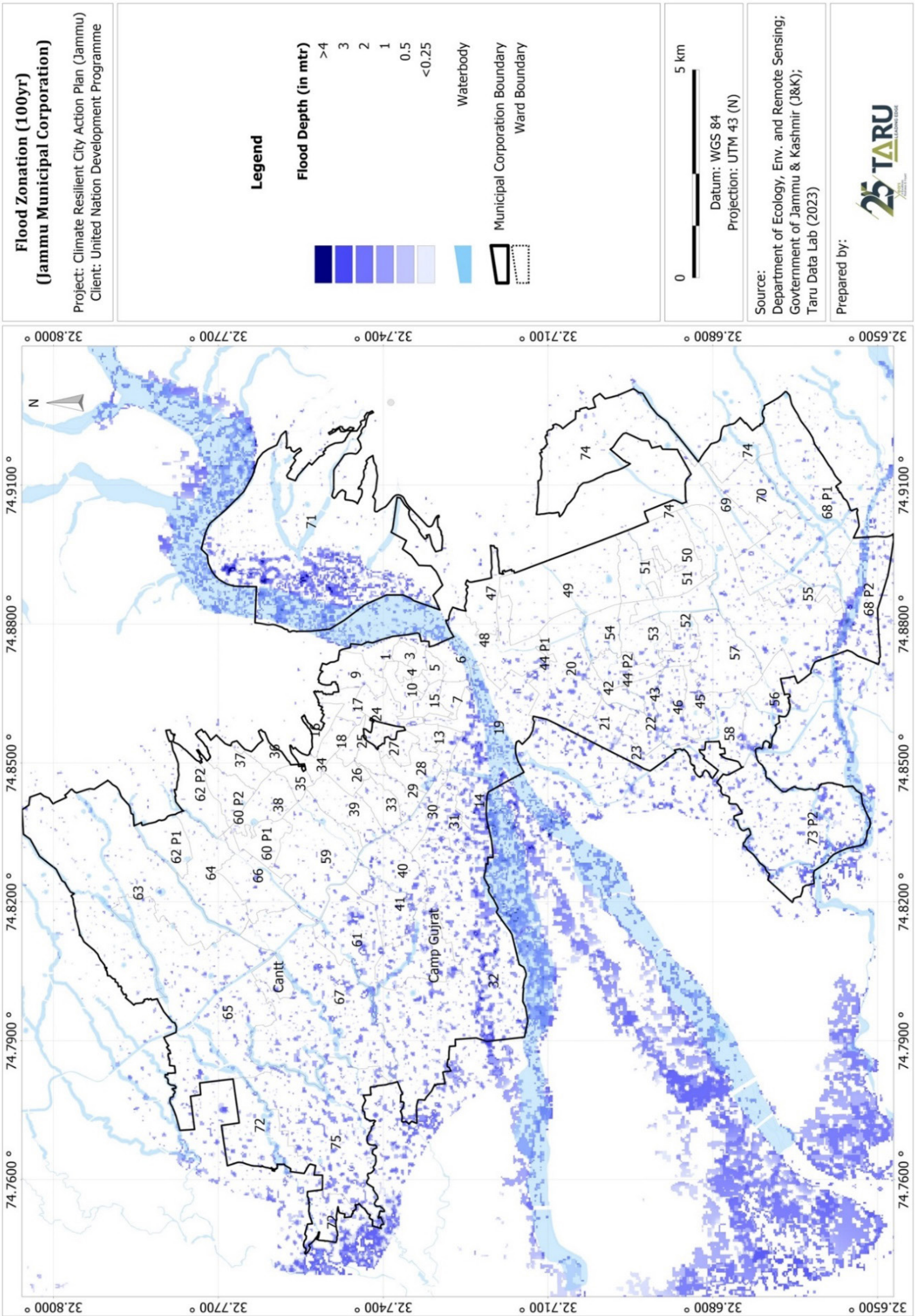


Figure 16: Combined (Pluvial & Fluvial) Floods (1 in 100 Year Return Period)

Critical assets vulnerable to flooding

For a city like Jammu, it is important to understand critical urban assets (such as Power, telecommunication, water, sewerage, fire stations, health infrastructure and road network leading to essential infrastructures such as hospitals, government buildings etc.), which are most important during disaster management.

Power: The average electricity consumption in the city is 208 million kWh. High electricity consumption is observed during July (233.9 million kWh) and low electricity consumption is observed in December (183 million kwh). The residential sector is the highest contributor to overall electricity consumption in the city (37%), followed by industries (25%), public water works and streetlights (15%), commercial (12%), and others (11%) (ICLEI, 2022). Power outages often accompany incidents of rainfall. Since the power lines are not laid underground yet, mishaps may occur if the power supply is not cut off during rain. But long hours of power cuts cause great distress to the public. It may also be noted that extreme summers in Jammu are often accompanied by long hours of load shedding. Even though J&K is largely dependent on hydroelectric power plants on its rivers for electricity generation, it experiences many power cuts. Since the summers here are pretty extreme, it increases people's dependency on fans and air conditioners for some relief causing stress on the power sector. The summers of 2022 saw long hours of power cuts in the range of 8 hours a day. Such cases cause great distress and dissatisfaction to the public.

While looking at the 1 in 100 years scenario, it is deduced that 7.1% of substations and 9.7% of transformers will be exposed to floods (Figure 17), since they are in close proximity to the high flood zone areas. These are found in Wards 19, 55, and 71. Also, the following substations are connected to critical infrastructure facilities, such as hospitals, fire stations, government buildings, etc. Canal substation in Ward 14, Talab Tillo in Ward 32, Boriain Bahu area in Ward 48, New Secretariat in Ward 10, Medical substation in Ward 27, SS Hospital in Ward 12, Wazahrat in Ward 5, Ashok Nagar in Ward 23, Railway Complex in Ward 48, Gorkhanagar in Ward 48, and Sidhra in Ward 71. These substations form a part of the city's critical infrastructure, where power supply over a large area gets disrupted, thus affecting a larger population. It is imperative to strengthen the resilience of these substations, so that they can withstand the effects of intense flooding while remaining accessible to the people.

Telecommunication: The telecommunication network serves as an early warning system used by emergency services in case of a hazardous event to warn and enquire about the safety of people in the affected areas. But, in such situations, this network also gets affected the most. The degree to which the telecommunication sector in Jammu is likely to get affected by flood is also high. Mobile towers across almost all the wards are expected to get affected if the city is exposed to flood. About 7.4% of mobile towers are exposed to floods (Figure 18). Thus, it is essential to strengthen the city's emergency response systems to reduce its vulnerability.

Fire Stations: The city of Jammu also has essential services like the fire and emergency services. The fire stations at Jammu are a part of the Fire and Emergency Services of Jammu and Kashmir. This department has been renamed to Fire and Emergency Services due to the wide gamut of responsibilities that has been ushered in on them. Their scope of work encompasses the duties of rescue and firefighting, disaster management, rescue from earthquakes, floods, landslides, avalanches, catastrophes, and conflagrations, road and rail accidents, air crashes, and underwater rescue, besides man-made disasters like war, air raids, and bomb blasts. There are five main fire stations found in Jammu city located in Roop Nagar, Kacchi-Chawni, Gandhi Nagar, Gangyal, and Hari Niwas. The level of access also varies temporarily through the day based on traffic and road conditions.

It is deduced that no fire station located in the city is exposed to floods, but the fire station in Ward 22 is located in close proximity to high flood zone areas. These fire stations form a part of the critical infrastructure of the city and it is essential to safeguard the people when they are affected by any hazard. So even if one fire station becomes non-functional, it would affect a larger population, exacerbating their vulnerability to the overlapping risks. Therefore, there is an urgent need to setup more fire stations in the city and strengthen the existing ones, to avoid any mishaps and fatalities in case of any unforeseen hazard events.

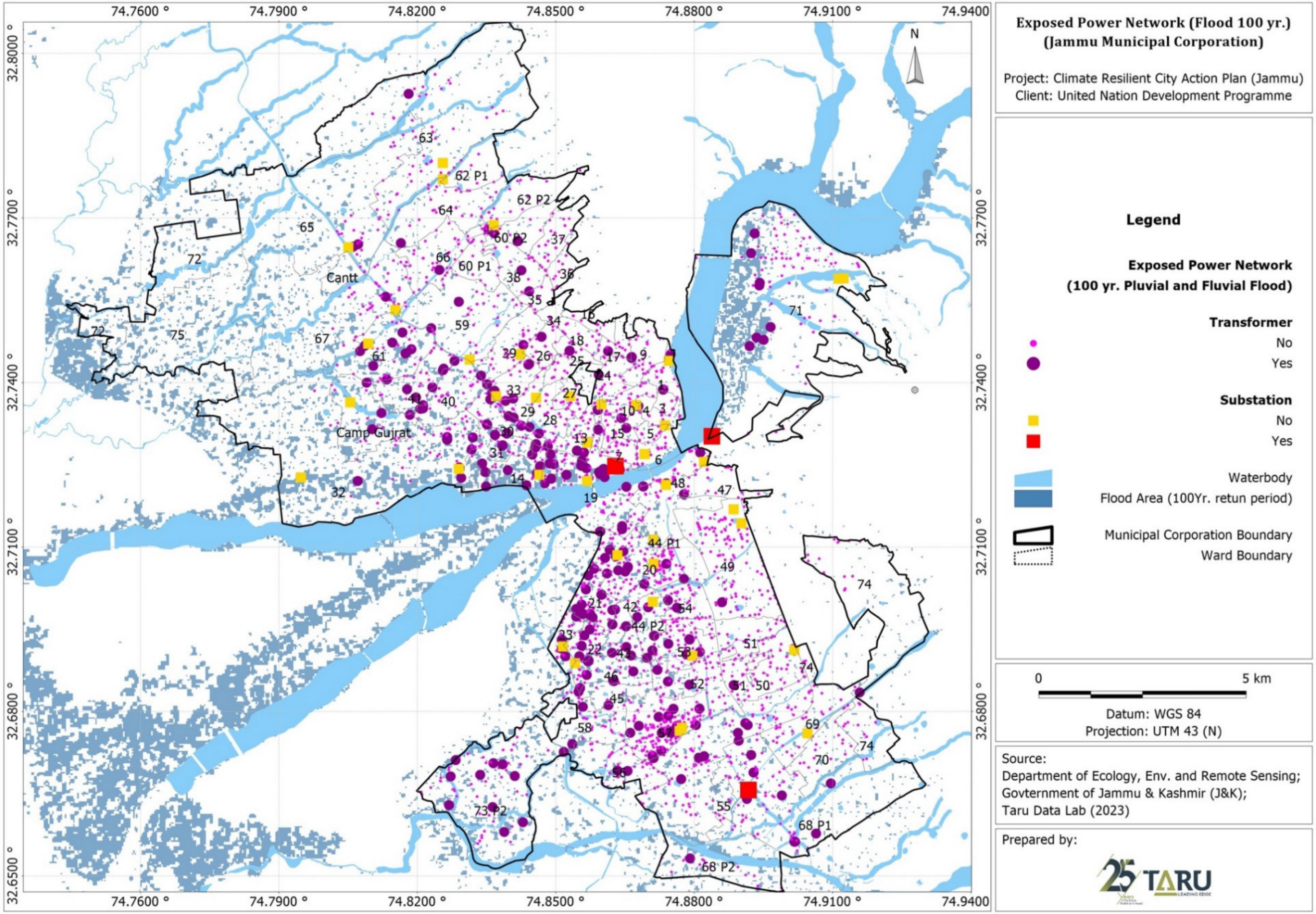


Figure 17: Exposed Power Infrastructure to floods (for 1 in 100 yr return period scenario)

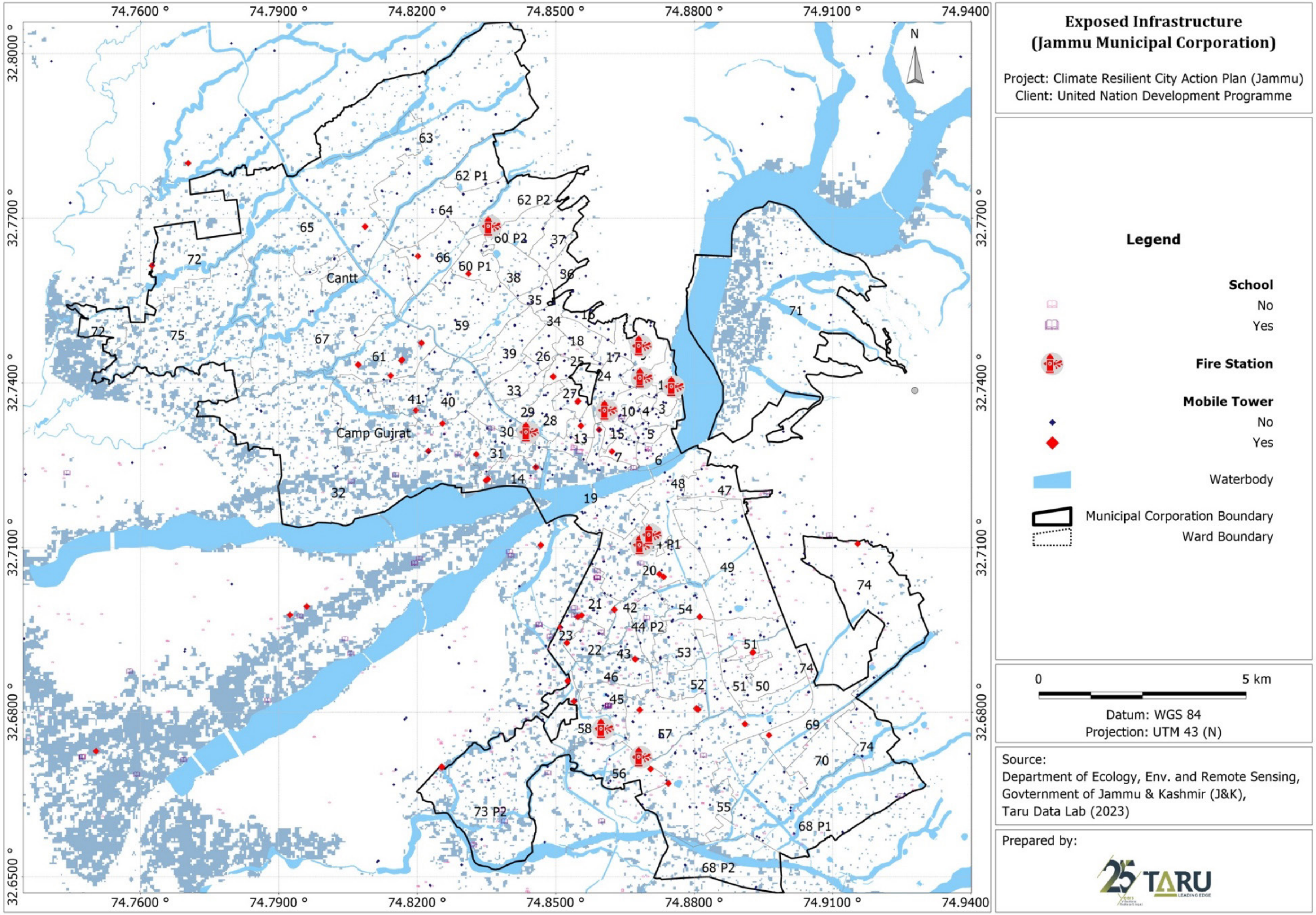


Figure 18: Exposed Infrastructure (Telecommunication, Fire Stations) to floods (for 1 in 100 yr return period scenario)

Sewerage: Sewage collection, treatment, and disposal in Jammu city is being managed by the Urban Environmental Engineering Department (UEED), J&K. About 45% of the city boasts of having a sewerage network, while the rest opts for septic tanks, reflecting the inadequacy of the system. At present, there is only one operational STP found in the city limits of Jammu, located in Bhagwati Nagar, with a mere 30 MLD capacity. At the same time, a total of 177 MLD of sewage is generated in Jammu city from the residential, commercial, and industrial sectors. The total length of sewerage network exposed to floods in a 1in 100-year scenario accounts for 5.8%. If the city witnesses heavy flooding, untreated sewage water passing through storm drains will amplify the effects of non-treatment of wastewater, as witnessed during rainy seasons. This surface runoff would get contaminated with the drainage system and ultimately get waterlogged, which would have severe health impacts.

Health Infrastructure: Jammu's population has access to a gamut of in-patient healthcare facilities (government, civic, and private-run). In total, Jammu has 71 government and civic run hospitals. The city also has many government and private hospitals, namely, GMC Jammu, Gandhi Nagar Hospital, Government Super Specialty Hospital, Sarwal Hospital, and Batra Hospital. There are 17 community health centres (CHCs), 19 primary health centres (PHCs) and 19 sub-centres (SCs), 7 medical aid centres and sub-centres (MACs), and 9 other general hospitals. A majority of the city boasts of having high accessibility to healthcare facilities, which is a big plus point in terms of adaptive measure of the city. But in the event of a disaster in Jammu, the city's population with easy access to healthcare facilities will be less vulnerable compared to other people living far from healthcare facilities. This reduction in level of accessibility during a disaster event increases the vulnerability and potentially impacts the timely medical aid and resources reaching to needful population, especially for the slum's population (due to limited financial resources and dependency on public transport).

While looking at the 1 in 100 years scenario (Figure 19), it is deduced that 8.5% of healthcare facilities will be exposed to floods, since they are close to high flood zone areas. They majorly include sub-centres and medical aid centres, found in wards 21, 31, 41, 55, 71, and 73. It is imperative to strengthen these healthcare centres, so they may withstand the effects of intense flooding while remaining accessible to the people.

Road Network Putting Critical Infrastructure at Risk: Floods reduce the accessibility and serviceability of the road transportation network, which is one of our most valuable infrastructure assets. Disruptive effects on the road system are intimately related to the vulnerability and resilience of the transportation network. Thus, while looking at the 1 in 100 year scenario with respect to exposure of floods, it is deduced that 161.10 km of the road network in the city is affected by floods (Figure 15). This accounts to 8.41% of the entire road network in the city. An estimate of 11.3% of government buildings and 22.2% of schools are exposed to floods. In such a scenario, it is not only the road network that gets affected, but also the city's other critical infrastructure (CI) that are put at risk, namely, health care facilities and fire stations. In case of a flood situation, accessibility to these CIs would get greatly affected as well, exacerbating the vulnerability of the road networks due to the overlapping risks. Hence, it is essential to assess the robustness of the transport network and take steps to make these more resilient, to avoid the degree of their vulnerability to floods in future.

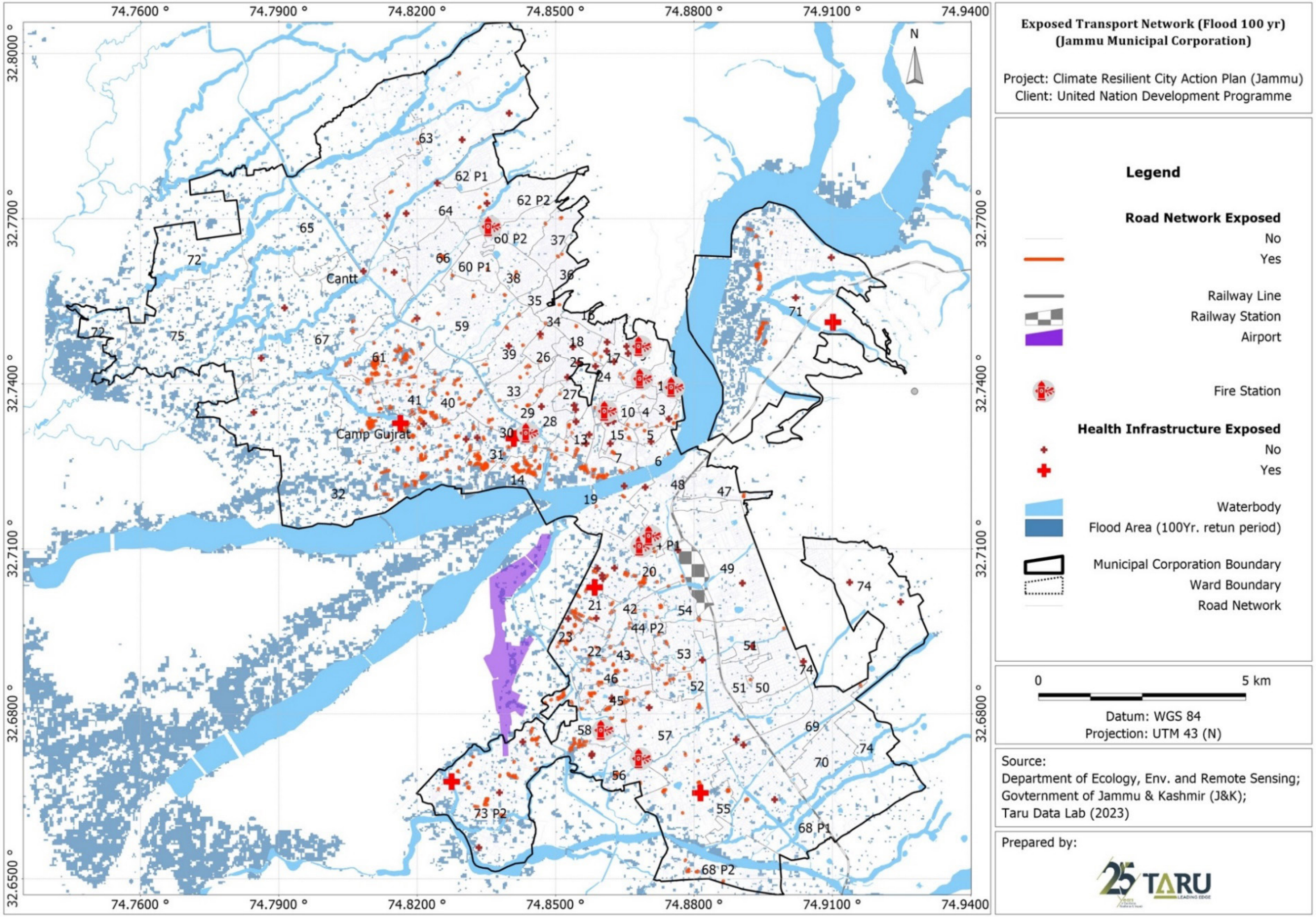


Figure 19: Exposed Transport Network to floods (for 1 in 100 yr return period scenario)

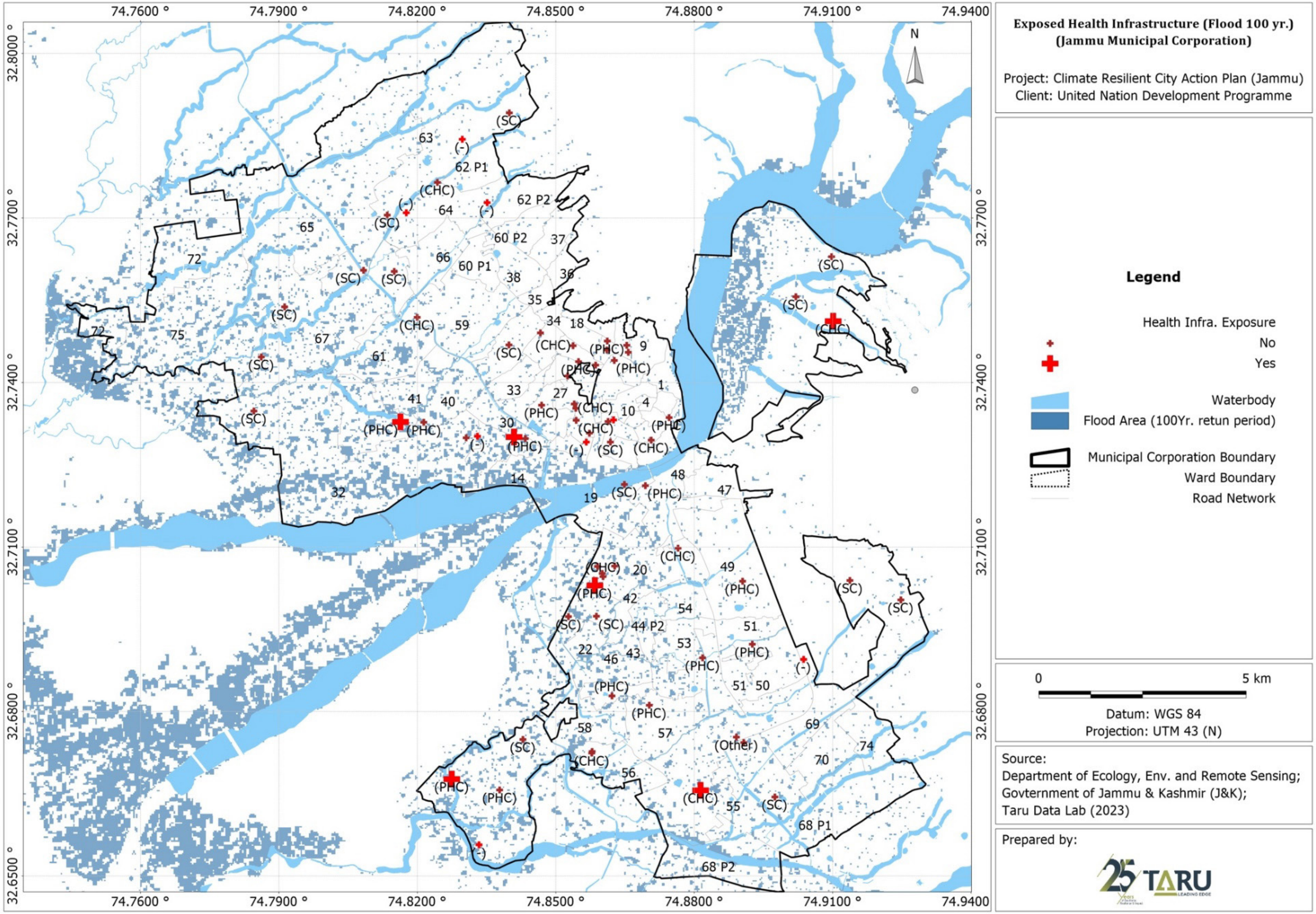


Figure 20: Exposed Health Infrastructure to floods (for 1 in 100 yr return period scenario)

3.2.2. Urban Heat Vulnerability

Urban Heat: The average mean surface temperature in Jammu for summer month is 40.61°C (of year 2022). The degree of temperature witnessed around the city varies with the kind of built-up area, density, recreational/green spaces, and proximity of the wards to water bodies. The lack of recreational/open space and presence of paved surfaces exacerbated, the UHI impact resulting in higher vulnerability. Delving deep into the scenario witnessed for Jammu, it is realized that the areas in the city with maximum residential and industrial land use are found to have the maximum temperature (41°C– 42°C), whereas the areas in close proximity to water bodies like Tawi or other canals and open spaces are found to have a lower temperature (23°C– 35°C respectively). A similar scenario is witnessed for areas with vegetation and forest cover (as shown in Figure 21), with the temperature ranging from 34°C–37°C respectively, stressing on the importance of having more open spaces and less built-up areas to avoid facing the wrath of environmental aggressors like increase in surface temperature.

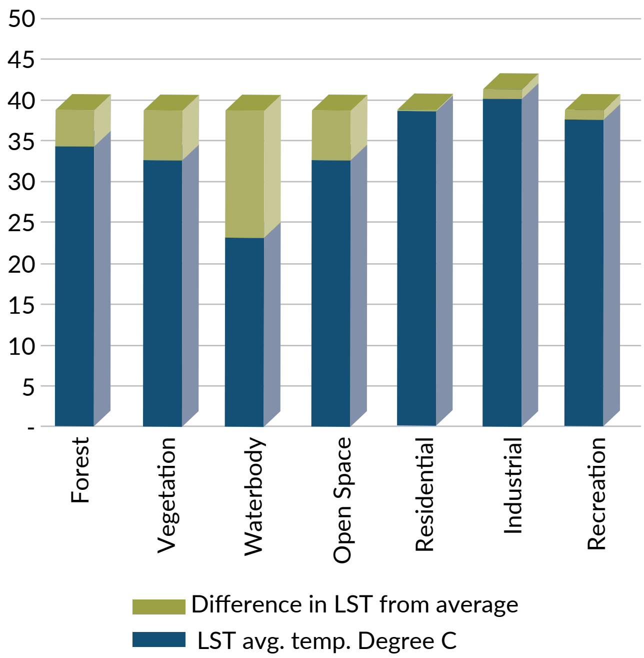


Figure 21: Difference in Land Surface Temperature

Land Use and Land Cover in Jammu: It is deduced that the older parts/establishments of the city, which do not have any more space to expand and have a small number of recreational areas, are already brimming with population and concrete structures, witnessing a higher land surface temperature. The study divides the city into two parts to understand the distribution of landuse pattern and LST. First would be the area to the north of Tawi and the other would be to its south. These two places are connected by Tawi bridge. Towards the north of Tawi, the wards at the forefront have an average maximum land surface temperature of >44°C (Figure 22). These wards together constitute 24.4% of the city's population.

A majority of these wards, namely, Panjtirthi, Jullaka Mohalla, Mast Garh, and Talab Khatikan, form a part of the old city and are hence characterized by narrow lanes, a high population density, and a highly functional central business district (CBD) with numerous shops for the purchase of dry fruits, shawls, and other essentials. This makes it a concrete jungle, justifying its high surface temperature and high density.

The UHI for industrial areas in the city is decreasing, compared to other categories which are increasing the UHI effect, with maximum increase observed in waterbodies, as shown in the Figure 22. Towards the south of Tawi, wards such as 21, 22, 23, 44, 45, 46, 49, 54, and 57 have a high surface temperature of >44°C. These wards constitute 11.5% of the city's population. Some of them are Shastri Nagar, Gandhi Nagar, Nanak Nagar, Digiana, and Trikuta Nagar that bear the brunt of high surface temperature. These areas, except Digiana, are some of the primarily residential localities of the city with upcoming CBD and commercial spaces, namely, Bahu Plaza and multiple restaurant chains. These areas have also reached their saturation point in terms of scope for newer developments due to lack of vacant plots, leaving people with no option but to increase the floor area ratio (FAR) of their housing structures.

Digiana is one of the few industrial and commercial areas of the city with primary focus on manufacture and maintenance of vehicles, thus generating a lot of heat and smoke in the process and hence a higher surface temperature. Combining the scenario witnessed on either side of River Tawi, the city has 36.0% of its population residing in wards with an average maximum land surface temperature of >44°C. The city wards with a lower temperature include Wards 9, 19, 39, 47, 48, 50, 55, 56, 58, 59, 60, 61, 68, 69, and 71. Most of these wards lie towards the outskirts. They are primarily residential, surrounded by recreational areas and water bodies, and have lower population density in comparison to the other wards. The population residing in these wards is about 24.43% of the city's population. Hence, it is imperative to say that to escape the havoc of heat island effect, it is essential to plan more recreational spaces that would act like much-needed breathing spaces within the city.

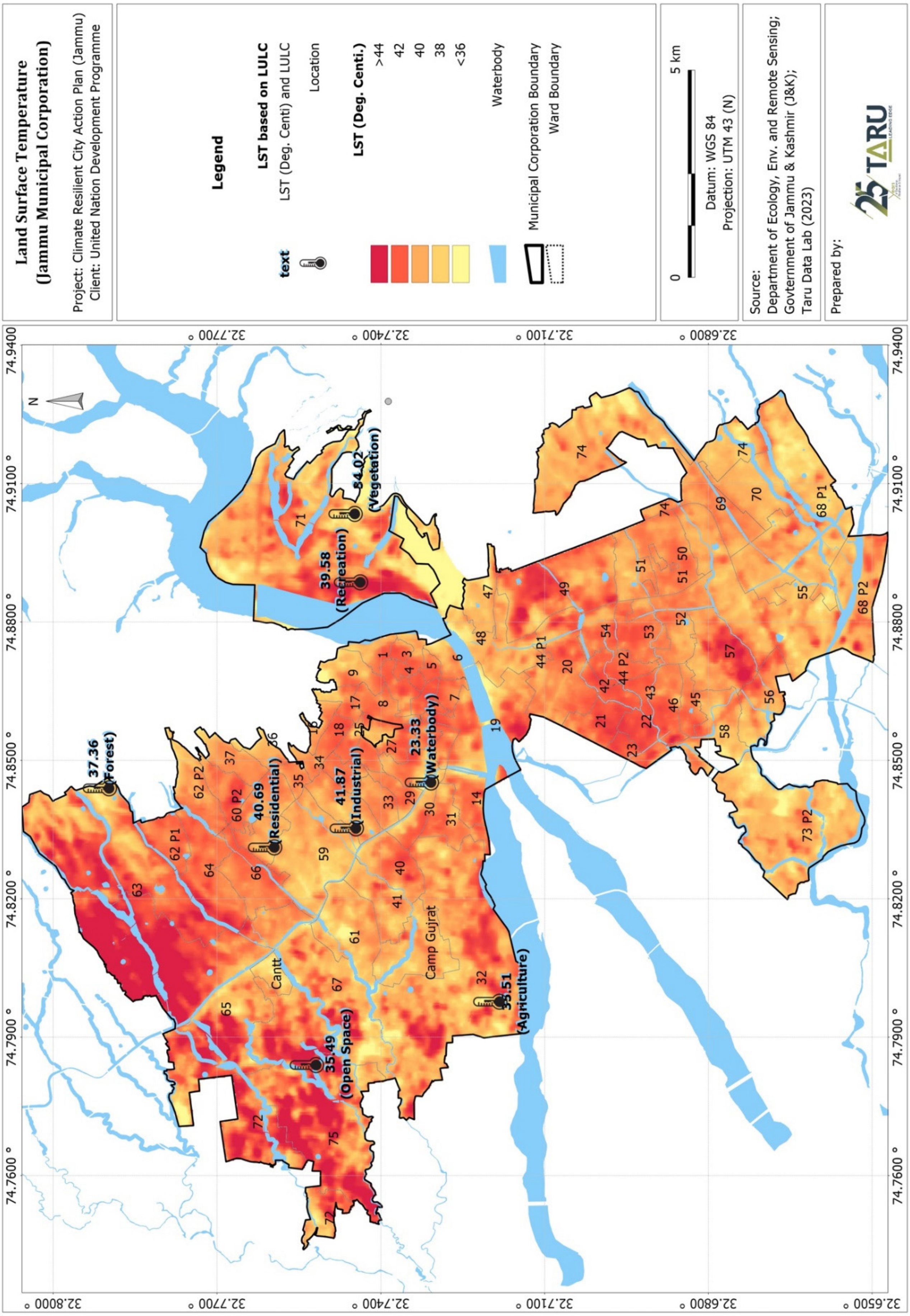


Figure 22: LST (Land Surface Temperature) for year 2022

3.2.3. Earthquake:

The existing stock of buildings in the old city of Jammu, especially in the old city is in dilapidated condition and could experience significant damage in the event of an earthquake. As in older cities, the city core typically has narrow and winding streets, thus hampering the rescue and relief efforts. Buildings in the newer parts of Jammu appear to be in a better condition but based on extensive discussions with the architect and engineering community of the city, they are neither designed nor detailed for earthquake resistance as prescribed by the earthquake codes of the country. Some of the constructions on slopes may need to be reviewed for stability in an earthquake. Another area of special concern is the built habitat along River Tawi in Jammu, or its landfills and riverbeds. These areas comprise deep soft soil deposits, which cause amplification of earthquake effect and may be prone to liquefaction in an earthquake and need to be specially addressed. A large stock of non-engineered reinforced concrete frame houses is being built in Jammu and elsewhere in Jammu and Kashmir, which may not perform adequately in an earthquake. To ensure the functioning of critical facilities, buildings occupying such facilities and falling in seismic zone IV/V need to be retrofitted. JDA must also develop a clear-cut retrofitting strategy at its level for this purpose (JTFRP, Taru, VMS, 2021).

3.2.4. Forest Fires:

All the locations found vulnerable to forest fires lie towards the city's outskirts, namely, Wards 9, 71, and 74, where these areas are mostly covered with dense forest reserves. Some areas in locations such as Ustad Mohalla, Sidhra, and Sunjwan are found to have a higher degree of exposure to forest fires, ranging from low to very high, primarily due to them being located in the outskirts, near the forest area. Herein, most of the exposed areas are the newer establishments of the city that were previously a part/in the proximity of dense forests like Sidhra. Due to lower population density, areas like Sidhra and Sunjwan (608 and 6096 persons per sq. km, respectively) have a lower risk of any accidents getting aggravated. Ward 9 (part of the old city), is characterized by narrow winding streets that do not allow for quick access to fire tenders and other response equipment and agencies, thus making the task of dousing fires quite challenging, despite its proximity to the fire stations. It is also a matter of great concern that apart from Ward 9, none of the wards is near the existing ten fire stations of the city. Therefore, it is essential to set up more fire stations in Wards, such as 71 and 74, with maximum exposed area and population to the risk of forest fire. The nearest fire stations to the forest fire-prone areas are Mubarak Mandi Fire Station in Ward 1 (1.4 km distance), Panjtirthi Fire Station in Ward 1 (1.2 km distance), Roop Nagar Fire Station in Ward 62 (1.7 km distance), Shaheedi Chowk Fire Station in Ward 48 (3.1 km distance), and Gandhi Nagar Fire Station in Ward 20 (2.3 km distance).

3.2.5. Landslides:

Jammu is exposed to seismic and flood-induced landslide hazard which has not been studied in great detail till date. Both earthquakes and floods trigger landslides, affecting movement on the critical Srinagar- Jammu National Highway. Therefore, exposure to landslide assessment for the current situation is done to understand the most likely vulnerable areas. Though the city is not much vulnerable to landslides, its outskirts, such as Sidhra, Panjtirthi, and Mast Garh, are more prone to landslides (Figure 23). The exposed area of the city lies in the eastern part of Jammu city, where Wards 1, 3, 6, and 71 are most exposed. Areas along major roads/highways, particularly those abutting the foothill, have a soil composition of boulder and loose silt. Especially, Circular Road, Sidhra Bye-pass Road, and eastern parts of the city are predominately hilly areas and are vulnerable to landslides, as has been a common occurrence during the rain of 2014. Places such as Sidhra (Ward 71), Panjtirthi (Ward 1, old city), Mast Garh (Ward 3, old city), Gujjar Nagar (Ward 6), and Bahu (Ward 48) are expected to be among the most affected. Sidra is another vulnerable ward that is among the more recent establishments of the city. Due to its location at the easternmost hilly terrain of the city, it was inhabited much later in comparison to the other parts of the city. It boasts of many key spots and critical social infrastructure, namely, the golf course, Batra Hospital, government degree college, and many new cafes that are being set up adjacent to the highway and bye-pass road.

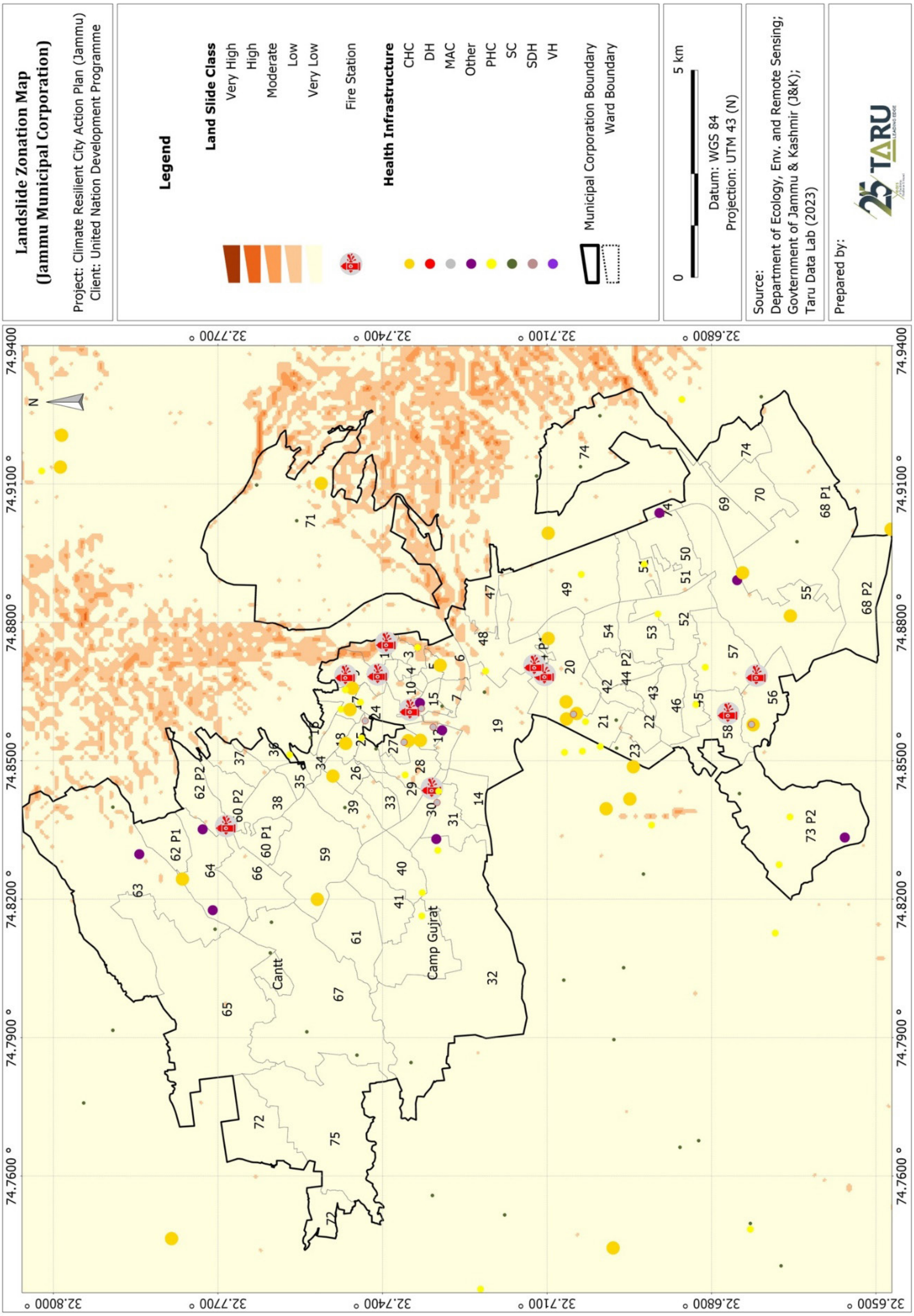


Figure 23: Exposure to Landslides

3.3. Ward-Level Relative Vulnerability

3.3.1. Natural Vulnerability

The hazard characteristics of that region highly influence natural vulnerability. Wards 32, 39, and 71 have a high natural vulnerability index. These wards have flooding exposure in this area of about 4.75 sq km (which is 37% of the total flood extent area) and flood depth ranges from 0.72 m – 1.43 m causing more water logging incidences in these wards. Also, the wards have less drainage network (about 10% of the total drainage network in the city) compared to other wards, hence adaptive capacity is less and there is a need for more drainage network. Sidhra (Ward 71) is also vulnerable to hazards such as landslides and forest fires due to its location towards the hilly terrain. Due to rapid urban growth with a sporadic growth pattern, hill slopes and areas close to forests like Ward 71 have been developed into built-up areas that have severe implications on such exposed areas, making them more vulnerable. Due to Sidhra being close to Tawi, many low-lying areas near the Tawi bridge, are exposed to flooding caused by incessant rain. The drainage channels have also fallen prey to the accelerated growth pattern because no standardised regulations are given to regulate development in the vicinity. Areas along major roads / highways, particularly areas abutting the foothill with a soil composition of boulders and loose silt was seen during the rain of 2014 along Circular Road, Sidhra Bye-pass Road and Eastern parts of the city which are predominately hilly areas. Whereas ward 32 is near the canal and was an erstwhile agricultural area making it more naturally vulnerable. Here the conglomerate of small boulders with silt often gets carried away by the incessant rains causing heavy damage to the services and infrastructure.

3.3.2. Social Vulnerability

Social vulnerability is a factor of the social and economic capacity of the society, which otherwise are indicators of coping capacity. The social vulnerability is highly correlatable with the slums, SC/ST and marginalised groups of the city who are more prone to hazards. The total number of slum households in Jammu city, according to the census of 2011 are 17,986. Out of 17,986 slums, the maximum no. of slums is found in ward no. 23 i.e. NaiBasti area. There are 2790 slum households in this ward, constituting 5.51% of the total slums in Jammu city (Sharma, 2018). The other areas having a high concentration of slums are Ward no.38 (Paloura) having 1780 slums i.e. 9.99% of the total slums of the city and ward no.11 (Mohalla Malhotra) having 1408 slums i.e.7.83% of the total slums in Jammu city (Sharma, 2018). The slums consist of people who have migrated from different states of India in search of better employment. Currently, about 5.4% of city's population is slums, which are scattered across various wards throughout the city, having 24,094 households (as given in chapter 1). Wards such as 32 and 71 have 23% and 30% of the SC/ST population as well as slums who are prone to water logging. Gole (Ward 32) is one of the most populated wards of the city with population density of 2,571 persons per sq km and slum population of 1902, making it more susceptible to hazard events than other wards.

3.3.3. Economic Vulnerability

Economic vulnerability of wards 32 and 65 is higher because the areas namely, Gol Gujaral (Ward 32) and Barnal (Ward 65) are amongst the older parts of the city, the population living herein can be mostly classified herein in the lower to middle-income groups, residing in old structures, thus limiting their ability to resist and adapt to hazards. Here, a number of low-income families reside in small dwellings and squatter settlements because they cannot afford to live in safer (more expensive) areas, limiting their access to amenities like the provision of drinking water, sanitation and electricity. These areas are developing in tandem with new businesses and emerging commercial areas. We also find a large number of small shops in Gol Gujaral. Still, since the ward has low-lying areas that are exposed to flooding caused by incessant rain, it could result in economic losses and increasing economic vulnerability impacting the residents' capacity to withstand and rebound from a hazard due to socio-economic factors.

3.3.4. Physical Vulnerability

The physical vulnerability housing structure would be the first to give people a sense of security, shelter, and solace. If the structure is temporary, it would be the first to get hit and wreak havoc on its dwellers. Ward 71 is a newer ward / establishment which has old structures, temporary structures and slums with poor roofing materials such as thatch roof, asbestos etc. in some places leading to high vulnerability to hazards such as windstorms or floods. About 5% of households in this ward have poor roofing materials such as thatch roofs or mud roofs.

3.3.5. Composite Vulnerability

The composite assessment shows that the highly vulnerable wards are 32 and 71, with the population accounting for 4.53% of the city. Wards 19, 39, and 65 are medium vulnerable, with a population of about 5.30%. Detailed values of CVI (Composite Vulnerability Index) are shown in Annexure 8.7. Figure 24 states various ward-wise and dimension-wise vulnerability maps.

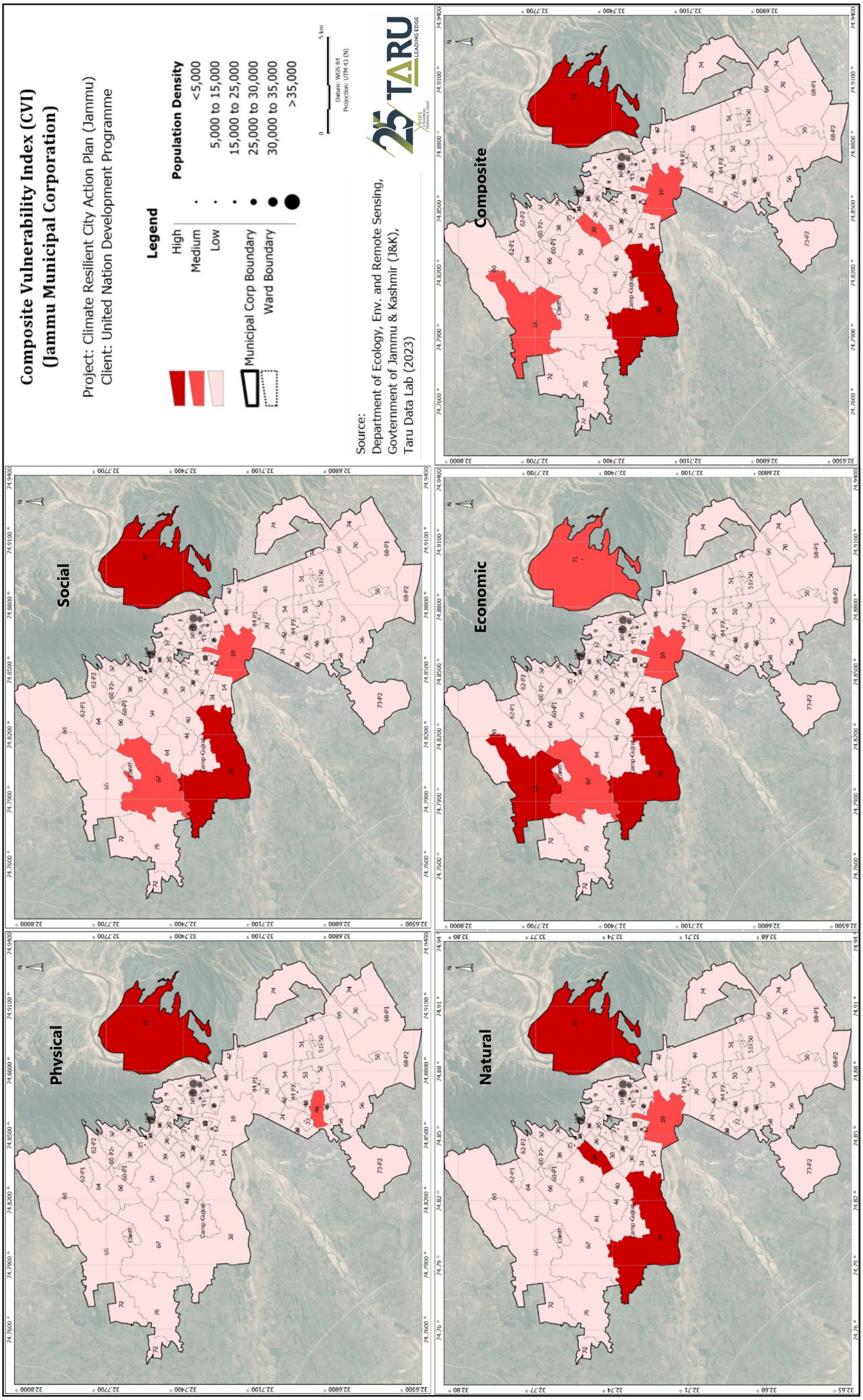


Figure 24: Vulnerability Indices - Jammu

CHAPTER

4

GHG EMISSION INVENTORY

4.1. Baseline GHG Emission Inventory

Summary: A Quick Overview of Jammu City's GHG Emissions

Greenhouse gas (GHG) emissions of Jammu city have been estimated for the Energy, Agriculture, Forestry and Other Land Use (AFOLU) and Waste sectors from 2005 to 2019. Year-on-year estimates help to understand the trends. As can be seen in figure 25, the economy-wide emissions of Jammu city witnessed a declining trend between 2005 and 2019. The decline in the economy-wide emissions can be attributed to decreasing emissions from AFOLU sector due to declining livestock population in Jammu city. Although the emissions from the energy sector progressively increased at a compound annual growth rate (CAGR) of ~3% between 2005 and 2019, however the significant decrease in AFOLU emissions resulted in the overall decline of the economy-wide emissions. The drivers of the energy sector are transport and residential categories, the details are given in the sectoral description. Waste sector emissions also increased over the reference period with a CAGR of ~2%. The year-on-year emissions. estimated for this plan are given in Table 6.

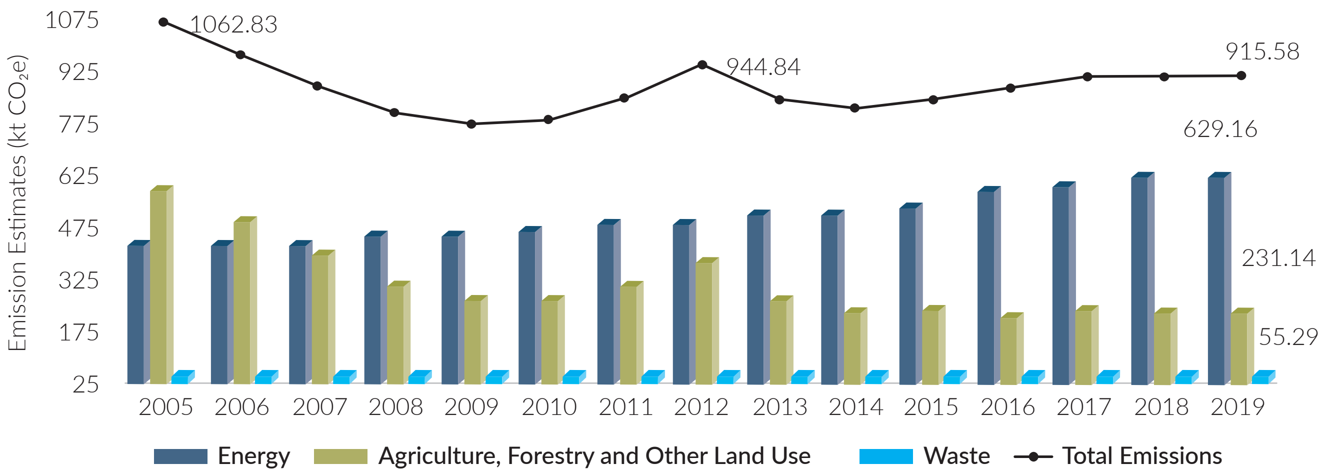


Figure 25: Economy-wide Emissions of Jammu City (2005–2019)

Table 8: Year-on-Year GHG Emission Estimates of Jammu City in kt CO_2e

Year	Energy	Agriculture, Forestry, and Other Land Use	Waste	Total Emissions
2005	419.76	603.27	39.81	1062.83
2006	430.21	501.72	40.57	972.50
2007	441.24	403.92	41.29	886.45
2008	452.86	318.51	41.97	813.34
2009	465.11	273.65	42.82	781.57
2010	478.00	272.99	43.44	794.43
2011	491.57	308.30	50.41	850.29
2012	505.85	387.96	51.03	944.84
2013	520.88	276.12	51.65	848.65
2014	536.69	238.62	52.27	827.57
2015	553.33	242.54	52.88	848.75
2016	591.54	229.30	53.41	874.25
2017	606.80	250.89	54.04	911.73
2018	616.53	240.47	54.66	911.66
2019	629.16	231.14	55.29	915.58

4.1.1. Assessment Methodology

4.1.1a. Overview

Emissions estimates for the city of Jammu cover key sectors and sub-sectors, as per the Intergovernmental Panel on Climate Change's 2019 Refinement to 2006 Guidelines for National Green House Gas Inventories (IPCC Guidelines) . The GHG inventory for Jammu city comprises of emissions from 11 categories across the sectors of Energy, Agriculture, Forestry, and Other Land-Use (AFOLU) and Waste for the years 2005-2019. Emissions from the industrial processes and product use (IPPU) sector are not included in the emission profile for Jammu city, as the presence of industries that lead to IPPU emissions (as per IPCC Guidelines) was not reported. However, the energy used in industries from the consumption of fuels (diesel) and the corresponding emissions are reported in the energy sector as per the IPCC guidelines.

GHG emissions inventory of Jammu city has been prepared as per IPCC guidelines "2019 Refinement to the 2006 IPCC Guidelines" for National Greenhouse Gas Inventories. Further, it is in line with the national-level inventory preparation for National Communications (NATCOMs) and Biennial Update Reports (BURs) and, wherever available, India-specific emission factors (from the two NATCOMs, INCAA Report, and the three BURs)[3] were used in place of default emission factors. To understand the regional dynamics and to make appropriate methodological assumptions in the absence of specific activity data, inputs from sectoral experts were incorporated. Detailed notes on the formulae used for each category estimates and information on variables, emission factors, etc. are given in the Annexure 8.2 to 8.5.

4.1.1b. Activity Data

Activity data for all the categories were sourced from government-approved data sets and/or peer-reviewed papers and is listed in Table 9.

Table 9: Source of Activity Data for the Categories Under Consideration

Sector	Category	Source of Activity Data
Energy	Transport	Comprehensive Mobility Plan, Jammu City, GoJ&K
	Manufacturing Industries	
	Residential	
	Agricultural	
	Commercial	
Agriculture, Forestry, and Other Land Use (AFOLU)	Agricultural Soil	Ministry of Chemicals and Fertilizers, APY Statistics of Farmer Welfare and Agriculture Development Department, GoI
	Enteric Fermentation	Animal Husbandry Department, Jammu, GoJ&K
	Manure Management	
	Land Use and Land Use Change and Forestry	Sharma, S; Kaur, H, 2016. Land Use/ Land Cover Changes and Urban Expansion in Jammu City, India and its Surroundings. International Research Journal of Environment Sciences. Vol 5 (5), 32–40
Waste	Municipal Solid Waste	Census Data, Jammu; Framework Document for Jammu City Climate Action Plan – Based on Urban System Gap Analysis June 2022, ICLEI in collaboration with UNDP and GoJ&K
	Domestic Wastewater	

4.1.1c. Emissions Factor

A summary of the methodological tier (IPCC Guidelines)) used for emissions estimation is given in Table 10. This table also provides information on the type of emission factors used, that is, India-specific (country-specific) or default (as given in the IPCC Guidelines)

[3] India's First National Communication to the UNFCCC, 2004; India's Second National Communication to the UNFCCC, 2012; Indian Network for Climate Change Assessment – INCCA's 2010 Report 'India: Greenhouse Gas Emissions 2007'; India's First Biennial Update Report to the UNFCCC, 2016; and India's Second Biennial Update Report to the UNFCCC, 2018

Table 10: Tier of Estimation and Type of Emission Factor by Key Source Category

IPCC ID	GHG Source & Sink Categories	Tier	Emission Factor
1.	**Energy**		
1A3	Transport	T1	CS
1A2	Manufacturing Industries	T1	CS
1A4b	Residential	T1	CS
1A4c	Agricultural	T1	
1A4a	Commercial	T1	CS
3.	**AFOLU**		
3A	**Livestock**		
3A1	Enteric Fermentation	T2	
	Cattle	T2	CS
	Dairy Cows (Indigenous and crossbred)	T2	CS
	Other Cattle or Non-Dairy Cows (Indigenous and Crossbred)	T2	CS
	Buffalo (Dairy and Non-Dairy)	T1	CS
	Horses and Ponies	T1	D
	Pigs		D
	Poultry	T1	D
3A2	Manure Management	T2	
	Cattle	T2	CS
	Dairy Cows (Indigenous and crossbred)	T2	CS
	Other Cattle or Non-Dairy Cows (Indigenous and Crossbred)	T2	CS
	Buffalo (Dairy and Non-Dairy)	T1	CS
	Horses and Ponies	T1	D
	Pigs	T1	D
	Poultry	T1	D
3B	**Land**		
3B1	Forest Land	T2	CS
3B2	Cropland	T2	CS
3B3	Grassland	T2	CS, D
3B5	Settlements	T2	CS, D
3B6	Other Land	T2	CS, D
3C	**Aggregate Sources and Non-CO_2 Emission Sources on Land**		
3C4, 3C5	Agricultural Soils	T1	CS
4	**Waste**		
4A2	Solid Waste Disposal	T1	CS, D
4D1	Domestic Wastewater	T1	CS, D

Note: T1: Tier 1; T2: Tier 2; T3: Tier 3; CS: Country-specific; PS: Plant-specific; D: IPCC default

4.1.1d. Limitations and Assumptions

There were several limitations pertaining to activity data and city-level information/data for multiple key source categories. Therefore, logical assumptions were used based on expert inputs and consultations. The limitations and assumptions are summarized category-wise in Table 11.

Table 11: Key Source Category-wise Limitations and Assumptions

Key Source Category (with IPCC Code)	Details	
Sector: Energy		
1A1ai Public Electricity Production	**Status**	No emissions occurred in this category
	Explanation	No fossil fuel-powered plants (supplying to grid) are present within the city limits
1A1cii Captive Power Plant	**Status**	Emissions from this category were not estimated
	Limitation	No data/information was available regarding captive plants within the city limits
	Assumptions	NA
1A2 Industrial Energy	**Status**	Emissions estimated
	Limitation	Emissions only from diesel consumption were estimated. There is lack of city-level data for other fuels (light diesel oil (LDO), natural gas (NG), coal etc.)
	Assumptions	9.57% of total diesel consumed in Jammu city is attributed to industrial energy (PPAC, 2013)
1A3 Transport	**Status**	Emissions estimated
	Limitation	Only road transport emissions were estimated. Railways and aviation could not be estimated due to lack of data Two fuels were considered: diesel &petrol CNG and aviation fuel data were not available
	Assumptions	63.3% of total diesel and 100% of petrol consumed in Jammu city is attributed to transport (PPAC, 2013) City-level fuel consumption data was available only from 2015 onwards. Therefore, for the period, 2005–2014, data was deduced using growth rate between 2015–2019
1A4Other Sectors **1A4a** Commercial; **1A4b** Residential; **1A4c** Agricultural	**Status**	Emissions were estimated
	Limitation	Fuels considered: diesel & LPG End-use (category-wise) fuel-wise consumption data was not available at city level
	Assumptions	21.96% of total diesel consumed in Jammu city is attributed to agricultural, and 1.82% and 3.35% is attributed to commercial and residential categories respectively (PPAC, 2013) 97% of total LPG consumed in Jammu city is attributed to residential and 3% is attributed to commercial categories (GHGPI, 2022) City-level fuel consumption data were available only from 2015 onwards. Therefore, for the period, 2005–2014, data were deduced using growth rate between 2015–2019

Key Source Category (with IPCC Code)	**Details**	
1B Fugitive Emissions from Fuels	**Status**	Emissions were not estimated
	Explanation	Major sources of emissions from this category (coal mines, oil refineries, pipelines etc.) are not present in Jammu city
Sector: Agriculture, Forestry, and Other Land Use (AFOLU)		
3A1 Enteric Fermentation	**Status**	Emissions were estimated
	Limitations	There are significant variations in the body weight and size of livestock across India, along with variations of feed intake that could not be fully captured due to lack of information The Jammu department's data on livestock population at the city level lacked sheep population figures
	Assumptions	Classification of livestock categories is based on the NATCOM reports. Details are given in the AFOLU methodology Annexure 8.3.
3A2 Manure Management	**Status**	Emissions were estimated
	Limitations	Information on manure management system in the city was not available (wet/dry system) There are significant variations in the body weight and size of livestock across India, along with variations of feed intake that could not be fully captured due to lack of information The Jammu department's data on livestock population at the city level lacked sheep population figures
	Assumptions	Classification of livestock categories is based on NATCOM reports. Details are given in the AFOLU methodology Annexure 8.3.
3B Land (Land Remaining and Land Converted to Other Categories for: **3B1** Forest Land **3B2** Cropland **3B3** Grassland **3B5** Settlements **3B6** Other Land)	**Status**	Emissions were estimated
	Limitations	City-level land use change matrix not available from official sources Relative stock change (FLU, FMG, FI) for a few sub-categories (grassland, settlements) are default and not country-specific Carbon stock of biomass and soil were considered, but that of deadwood, litter, etc. were not covered
	Assumptions	Land use change matrix obtained from literature review
3C1a Biomass Burning in Forest Land	**Status**	No emissions occurred in this category
	Explanation	No biomass burning in forest land reported in Jammu city
3C1b Biomass Burning in Cropland	**Status**	No emissions occurred in this category
	Explanation	No biomass burning in crop land reported in Jammu city (based on inputs from stakeholder consultations)

Key Source Category (with IPCC Code)	Details	
Agricultural Soils (**3C4** Direct N2O Emissions from Managed Soils; **3C5** Indirect N2O Emissions from Managed Soils)	**Status**	Emissions were estimated
	Limitations	Emissions only from the use of fertilizers were estimated City-level fertilizer consumption data were not available
	Assumptions	City-level fertilizer consumption data are deduced by applying per hectare fertilizer used on the agriculture land of the erstwhile state of J&K to the total agricultural land of Jammu city
3C7 Rice Cultivation	**Status**	Emissions were not estimated
	Explanation	Information on areas under rice cultivation within the city boundary was not available Information on irrigation regimes/water ecosystem was not available
Sector: Waste		
4A Solid Waste Disposal	**Status**	Emissions were estimated
	Limitations	Year-on-year waste generation and waste treatment data were not available for Jammu city Several factors/fractions required for the computation of emissions were not available for the city, therefore, district/state-level fractions were used, like, degradable organic carbon, proportion going to landfill etc.
	Assumptions	Population for the years in between those reported by the census is estimated using CAGR District/state-level fractions have been used, where required
4D1 Domestic Wastewater Treatment and Discharge	**Status**	Emissions were estimated
	Limitations	Year-on-year domestic wastewater generation data was not available for Jammu city Several factors/fractions required for the computation of emissions were not available for the city, therefore, district/state-level fractions have been used, like protein intake, degree of utilization (toilet/ sewerage system types) etc.
	Assumptions	Population for the years in between those reported by the census is estimated using CAGR District/state-level fractions have been used, where required
4D2 Industrial Wastewater Treatment and Discharge	**Status**	Emissions were not estimated
	Explanation	Whether or not there are any industries (as defined by the IPCC) within the city limits is unknown Year-on-year wastewater generation or even production data were not available for industrial units operating in city boundaries
Sector: Industrial Process and Product Use (IPPU)		
All Categories of IPPU	**Status**	Emissions were not estimated
	Explanation	Whether or not there are any industries producing IPPU emissions (as defined by the IPCC) within the city limits is unknown No data was available on industrial production within the city boundary

4.1.2. Trend Analysis

Sectoral Emissions

4.1.2a. Energy Sector

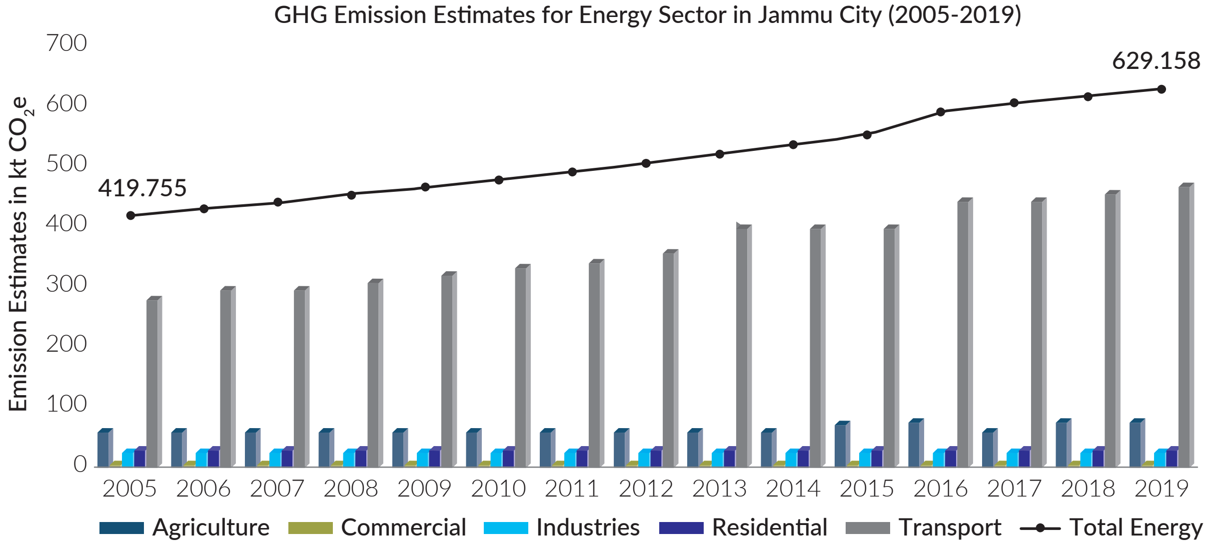


Figure 26: GHG Emission Estimates of Energy Sector (2005–2019)

The Energy sector typically comprises emissions from fuel combustion and fugitive emissions. Fuel combustion includes emissions from public electricity generation, transport, industries, captive power plants, agriculture, commercial, and residential categories. Fugitive emissions are due to fuel production.

For Jammu city, Energy sector emissions were estimated for fuel combustion from transport, industries, agricultural, commercial, and residential categories. Emissions from the energy sector increased at a CAGR of ~3% from 419.76 kt CO_2e in 2005 to 629.16 kt CO_2e in 2019. Energy emissions of Jammu city accounted for ~69% of the economy-wide emissions in 2019 (figure 25). Within the Energy sector, transport category was the major contributor to GHG emissions with a share of ~75% in 2019. This was followed by agriculture and industries categories with shares of ~13% and ~6%, respectively (figure 27).

Note: No sources of public electricity generation, captive power plants, or fugitive emissions (coal mines or refineries) were identified within the city.

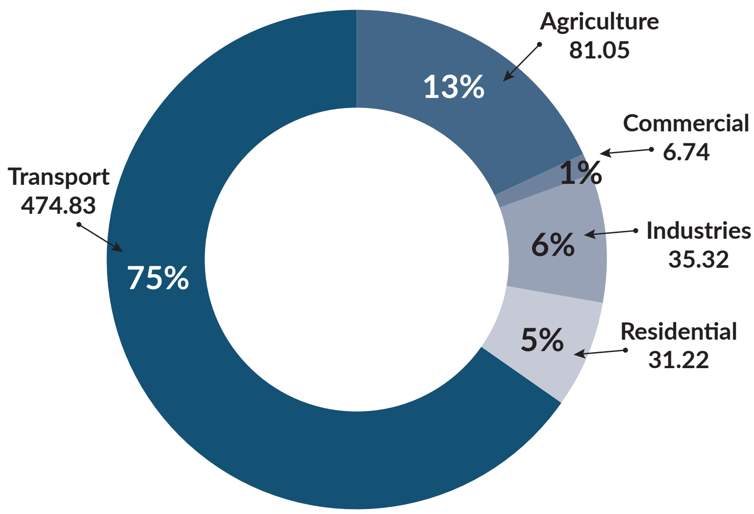


Figure 27: Percentage Contributions and Emission Estimate (kt CO_2e) to Total Energy Emission

4.1.2b. Agriculture, Forestry, and Other Land Use (AFOLU)

Emissions from the Agriculture, Forestry, and Other Land Use (AFOLU) sector arise from three main sub-sectors: livestock, land and aggregate sources and non-CO_2 emission sources on land. In Jammu city, all the three sub-sectors were net emitters throughout the reference period. The AFOLU sector contributed to almost ~25% of the total emissions of Jammu city in 2019[4]. Emissions from AFOLU sector declined at rate of ~7% compounded annually from 603.27 kt CO_2e in 2005 to 231.14 kt CO_2e in 2019. Decline in emissions from the AFOLU sector was due to decrease in emissions from the livestock sub-sector[5]. As seen in figure 28, a spike in 2012 is observed due to an increase in the population of crossbred cattle and buffaloes in Jammu city.

The livestock sub-sector had the maximum share of ~76% to total AFOLU emissions in Jammu city in the year 2019. From the livestock sub-sector, enteric fermentation was the major contributor of emissions across the reference period with an average share of ~72% to the AFOLU emissions. However, the contribution of emissions from this category declined at a rate of 2% (compounded annually) from 496.83 kt CO_2e in 2005 to 156.06 kt CO_2e in 2019. As described in Table 11, the activity data for estimating livestock emissions is sourced from Animal Husbandry Department, Jammu. The data statement (Annexure 8.8) shows a significant increase in the crossbred non-dairy adult population and buffalo non-dairy adult population for the years 2013 to 2017 and this is also reflected in the emissions of livestock.

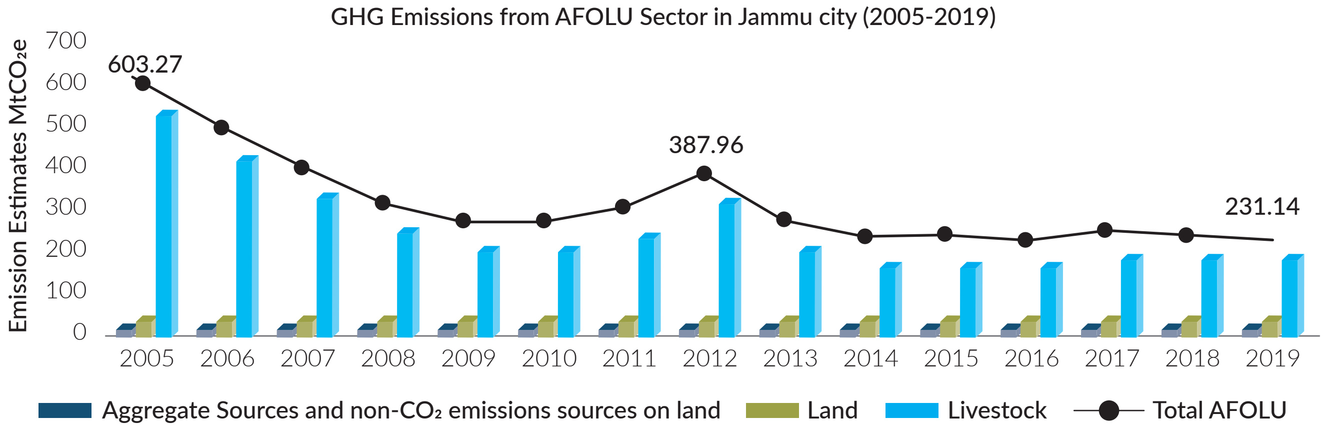


Figure 28: Emissions from AFOLU Sector (2005–2019)

From the aggregate sources sub-sector, the share of emissions from agricultural soils increased from ~0.63% in 2005 to ~2.63% of the total AFOLU emissions in 2019. From the land sub-sector, the share of emissions from the settlements to total AFOLU emissions increased from ~4.4% in 2005 to ~11.6% in 2019 and the share of forest land emissions increased from ~2.5% in 2005 to ~6.6% in 2019. Emissions from other land had a share of ~1% in the total AFOLU emissions in 2019 (figure 29 and figure 30).

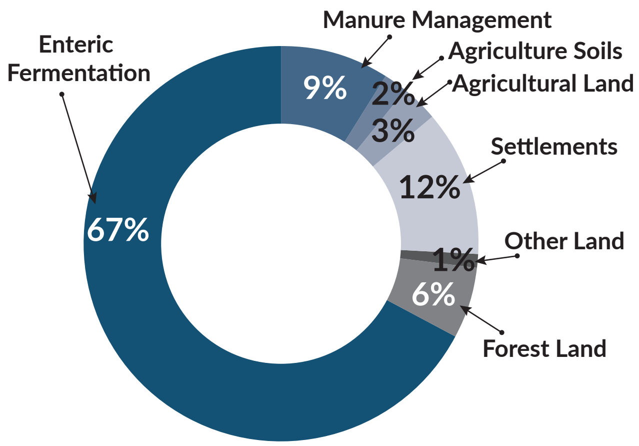


Figure 29: Category-wise Share of Emissions in AFOLU Sector (2019)

[4] Note: Emissions from rice cultivation were not estimated due to lack of required data availability. Emissions from biomass burning from cropland and forest fires were not included, as biomass burning in cropland and forest land were not reported in Jammu city (based on inputs from stakeholder consultations).

[5] Livestock emission estimates are based on Jammu city livestock population data provided by the Department of Animal Husbandry (Jammu office). The trend observed in the livestock population of Jammu city is more or less similar to the Jammu district livestock population.

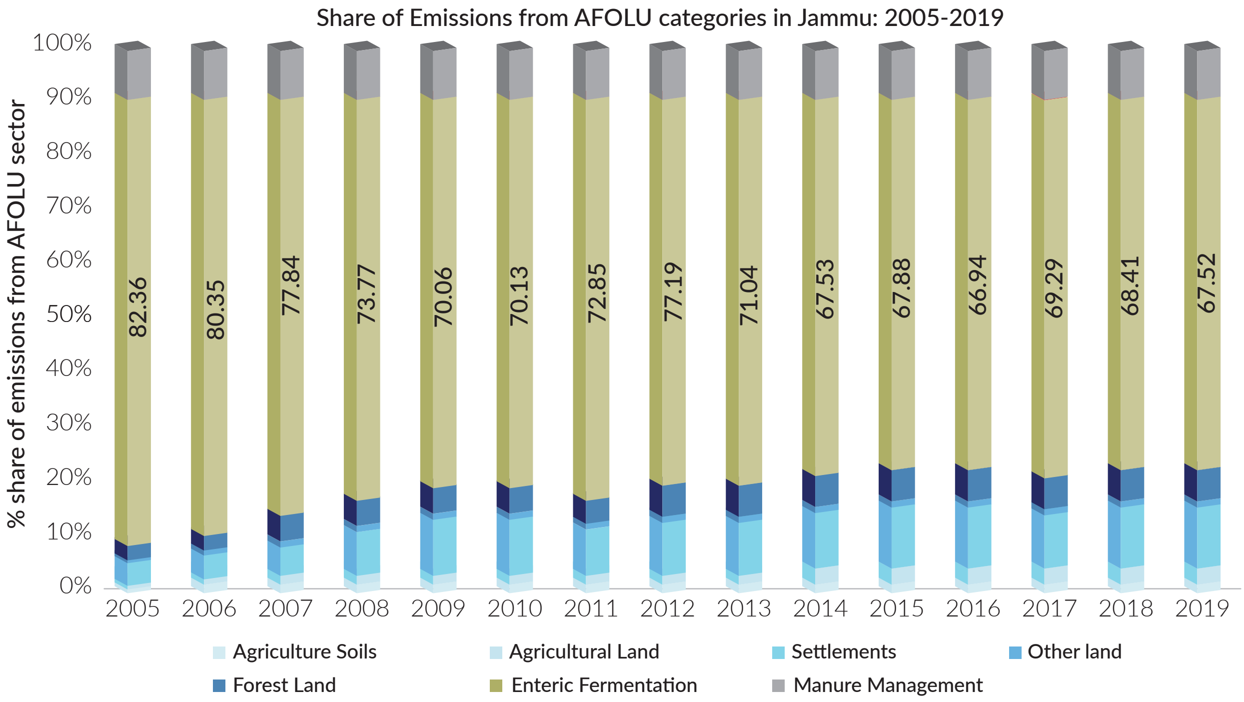


Figure 30: Percentage Share of Categories in AFOLU Sector (2005–2019)

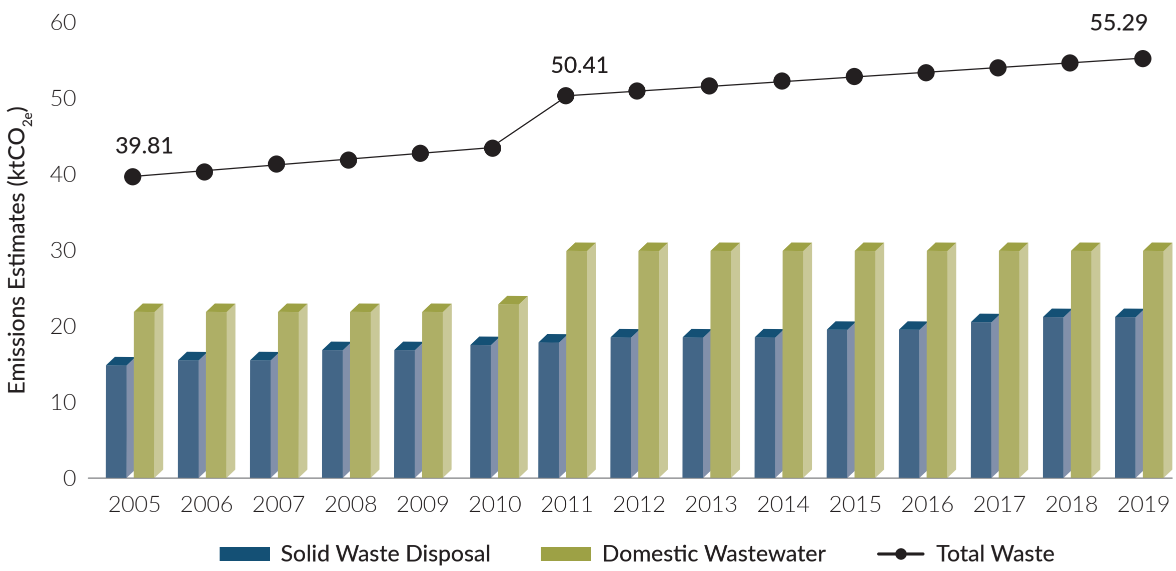


Figure 31: GHG Emission Estimates of Waste Sector (2005–2019)

4.1.2c. Waste Sector

Solid waste disposal, domestic wastewater, and industrial wastewater are the key sources of GHG emissions from the waste sector[6]. The waste sector contributed to almost ~6% of the total emissions of Jammu city in 2019. GHG emissions from the waste sector of Jammu city grew at a CAGR of ~2% from 39.81 kt CO_2e in 2005 to 55.29 kt CO_2e in 2019, as illustrated in figure 31. A sudden jump in the total waste sector emissions is seen between 2010 and 2011 due to change in the degree of utilization (toilet/ sewerage system types used), as reported in census 2011. Discharge of untreated wastewater, anaerobic treatment plants, and use of septic tanks are the key drivers of emissions from domestic wastewater sub-sector. Domestic wastewater had a share of ~58% in the total waste sector emissions of Jammu city in 2019. Approximately 42% of the waste sector emissions were from solid waste disposal, which grew at an estimated CAGR of ~3% from 16.37 kt CO_2e in 2005 to 23.17 kt CO_2e in 2019 figure 32.

[6] Note: Emissions from industrial wastewater were not estimated because it could not be determined whether industry categories as listed in NATCOM/BUR (that lead to GHG emissions from industrial wastewater) were present in the city

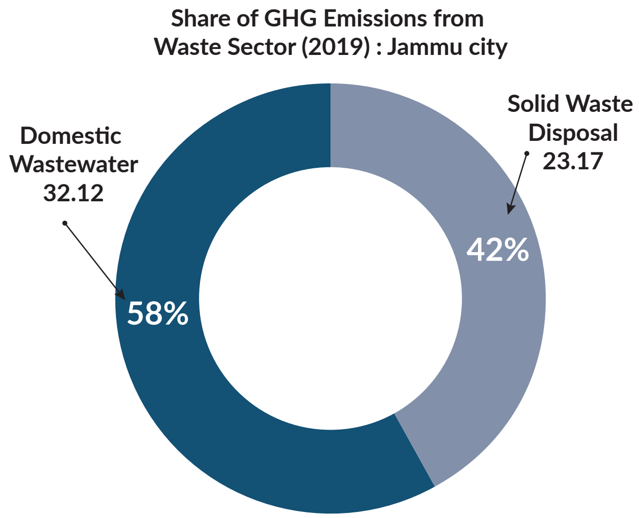


Figure 32: Share and Emission Estimates (kt CO_2e) of Sub-Sectors in Total Waste Sector Emissions

4.1.2d. Economy-wide emissions

The sectors described in sections 2.1.2a, 2.1.2b and 2.1.2c have been summed to give the economy-wide emissions as shown in figure 33. As discussed in session 2.1.1 Jammu city's GHG emissions declined from 1062.83 kilotonnes of CO_2 equivalent (kt CO_2e) in 2005 to 915.58 kt CO_2e in 2019, at a CAGR of 1%, Despite a steady rise in Energy emissions, the overall economy-wide emissions declined as a result of the significant decrease in emissions from the AFOLU sector (due to livestock emissions). Emissions from the Waste sector marginally increased during the reference period from 39.81 kt CO_2e in 2005 to 55.29 kt CO_2e in 2019[7].

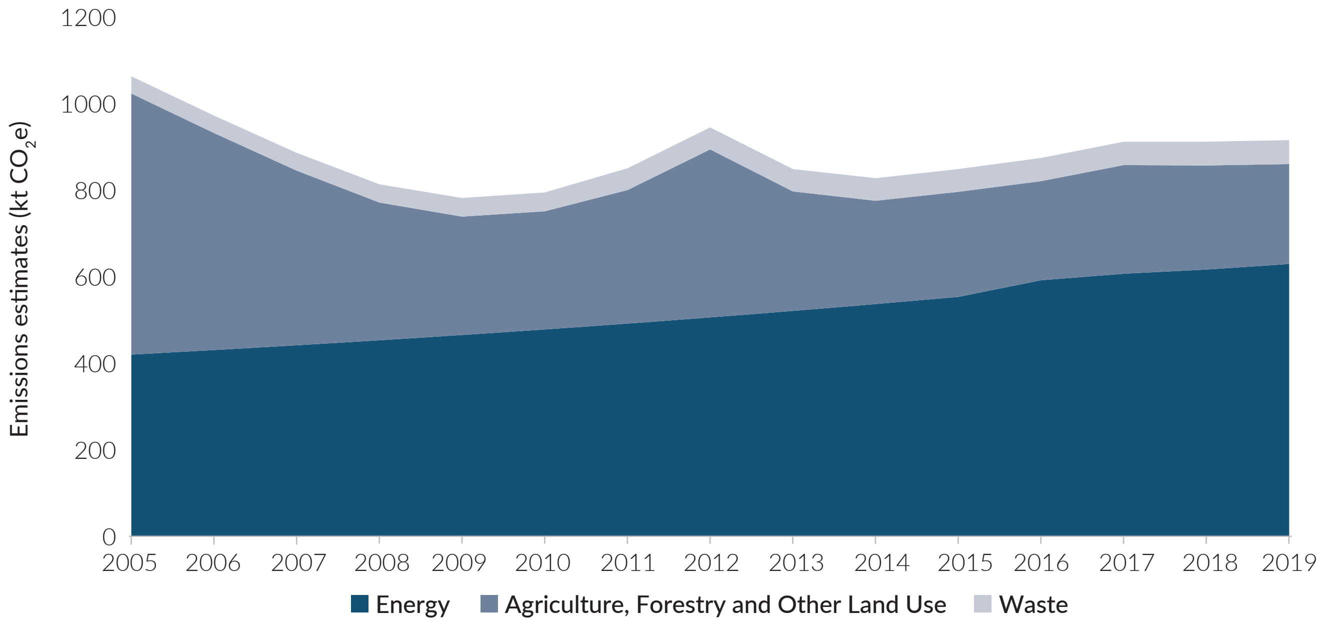


Figure 33: Economy-wide emissions of Jammu city (2005-2019)

[7] Note: IPPU is not estimated in the inventory due to limited data available on industries within city limits.

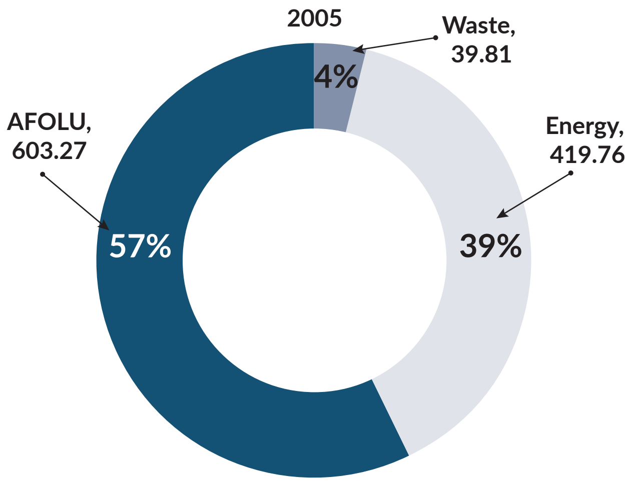


Figure 34: Sector-wise Contribution (kt CO_2e) and Percentage Share to Economy-wide GHG Emissions of Jammu City, 2005

4.1.2e. Sector-wise Contribution (kt CO_2e) and Percentage Share to Economy-wide GHG Emissions of Jammu City

In 2005, the share of AFOLU sector emissions in economy-wide emissions was ~57 percent. This was followed by energy and waste sectors with shares of ~39% and ~4% respectively. In 2019, the share of AFOLU sector emissions declined to ~25%. While the share of Energy sector emissions increased to ~69%. The share of Waste sector emissions increased from ~4% in 2005 to ~6% in 2019 (figure 34 and figure 35).

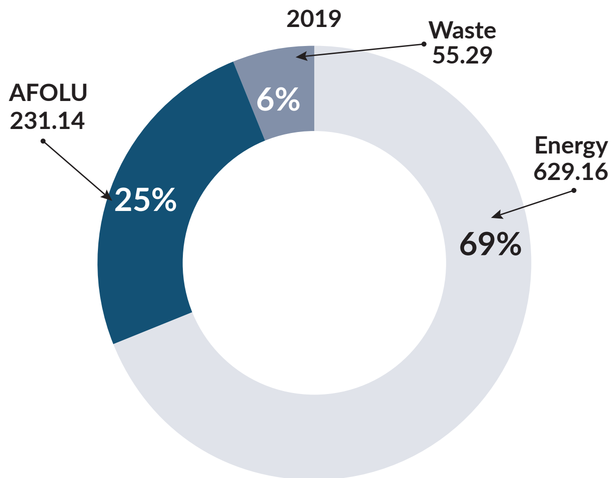


Figure 35: Sector-wise Contribution (kt CO_2e) and Percentage Share to Economy-wide GHG Emissions of Jammu City, 2019

4.1.2f. Per Capita Emissions of Jammu City

Figure 36 shows the trend of Per capita emissions of Jammu city and India between 2005 and 2019. Per capita emissions of India have increased at a CAGR of 3.40% whereas that of Jammu city decreased at a rate of 1.60%, compounded annually between 2005 and 2019. The per capita emissions of Jammu city decreased due to decrease in overall GHG emissions, which in turn was due to decline in AFOLU emissions, coupled with increasing population of the city.

AFOLU sector emissions also decreased for India, however, significant increase of emissions from Energy sector and other sectors have resulted in overall increase in economy-wide emissions and per capita emissions at the national level.

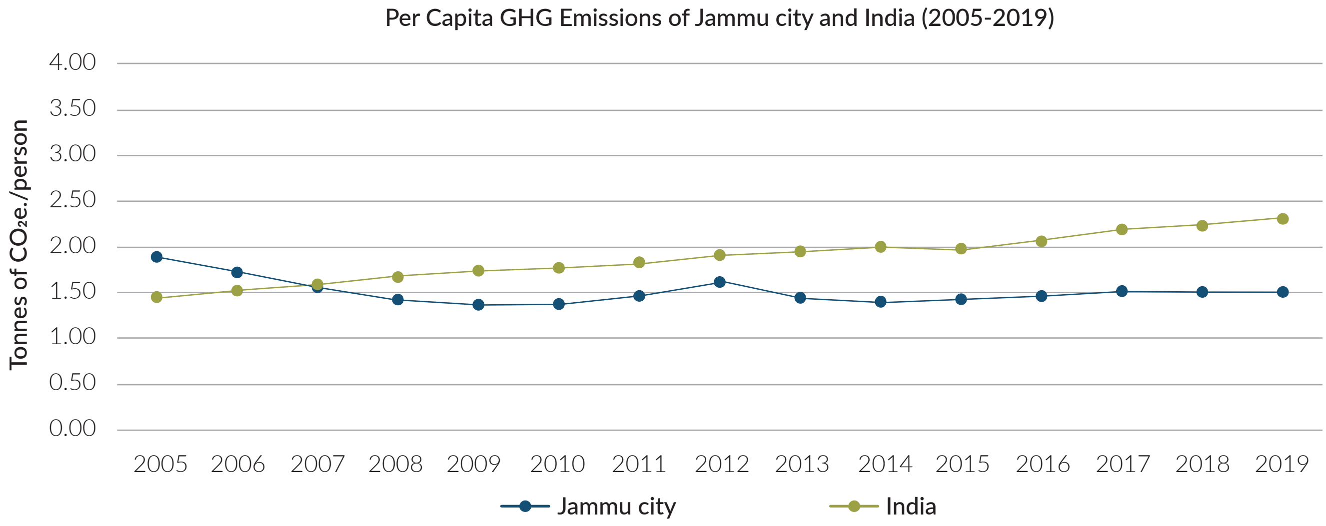


Figure 36: Per Capita GHG Emissions of Jammu City and India

4.1.2g Projection 2030

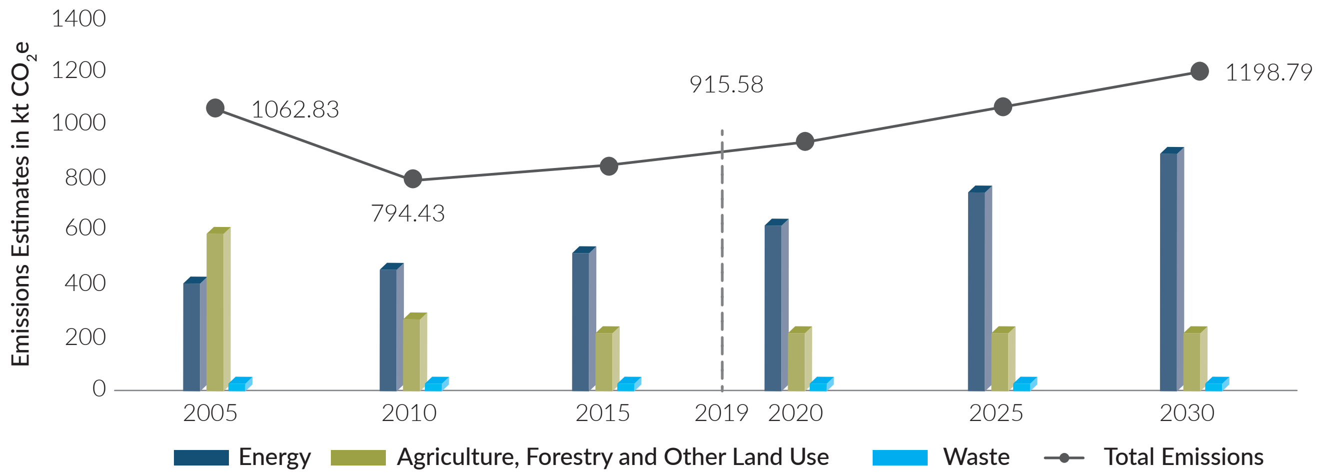


Figure 37: GHG Emissions Projection, 2030

GHG emission projections for Jammu city from 2020 to 2030 are based on sectoral emissions trends between 2014 and 2019. Under the BAU scenario, the emissions are expected to increase almost 1.3 times or ~31% from 2019 level (915.58 kt CO_2e). As per the projections, Energy sector will be the key driver of emissions in the city, accounting for ~77% of the total GHG emissions in 2030. The emissions from Waste sector are projected to increase ~14% whereas almost 7% decrease in GHG emissions can be observed from AFOLU sector in 2030 from 2019 level (see figure 37).

4.1.2h. Gas-wise Inventory for Jammu City (2019)

For 2019, gas-wise emissions from all the categories are summarized in Table 12. This table provides the carbon dioxide equivalent of emissions from all categories.

Table 12: GHG Inventory for Jammu City (2019)

Greenhouse Gas Sources Categories[8]	CO_2 Emissions (Tonnes)	CH_4 (Tonnes)	N2O (Tonnes)	CO_2e[9] (Tonnes)
Total City Emissions	650833.69	13379.06	71.46	916211.02
Energy[10]	600532.03	1007.80	24.06	629157.62
Transport	465124.10	123.06	22.98	474831.51
Agricultural	80615.72	10.88	0.65	81046.53
Commercial	6701.71	0.90	0.05	6737.45
Residential	12958.80	868.28	0.10	31222.66
Industrial	35131.71	4.74	0.28	35319.49
AFOLU	50301.66	10196.39	16.20	231135.40
Agricultural Soils	NA	NA	15.32	4749.29
Enteric Fermentation	NA	9339.67	NA	156063.07
Manure Management	NA	856.72	0.882	20021.38
Agriculture Land	6136.41	NA	NA	6136.41
Settlements	26789.65	NA	NA	26789.65
Other Land	2155.11	NA	NA	2155.11
Forest Land	15220.49	NA	NA	15220.49
Waste	NA	2174.87	31.20	55918
Domestic Wastewater	NA	1071.68	31.02	32302.00
Solid Waste Management	NA	1103.19	NA	23616.00

NA – Not Applicable

[8] Global warming potential (GWP) AR2 values are used to estimate the CO_2e of CH_4, N_2O, and CO_2.AR2 GWP values are used because India's NATCOM and BUR reports use AR2 GWP figures to estimate national inventory emissions
[9] Due to decimal rounding off, the total CO_2e (in tonnes) may slightly vary
[10] Energy emissions pertaining to fuel combustion emissions were estimated

CHAPTER 5

CLIMATE RESILIENT ACTION PLAN

Chapter 5: Sectoral Plans – Actions & Implementation Strategies

The sectoral action plan focuses on power, energy and habitat sector, sustainable transport, agriculture and green spaces and waste management as the key sectors for Jammu city. The resilience interventions included in the action plan are informed by the baseline sectoral GHG emissions and identified climate vulnerabilities. Sections 5.1 to 5.4 provide information on sectors that make up the CRCAP of Jammu.

For each of the sectors, the specific timeframe, priorities (short and medium-long term), entities that are primarily responsible for the implementation and various schemes and programmes that can support the intervention, funding sources, mitigation potential, indicators and measure outcomes are indicated (as shown in figure 38).

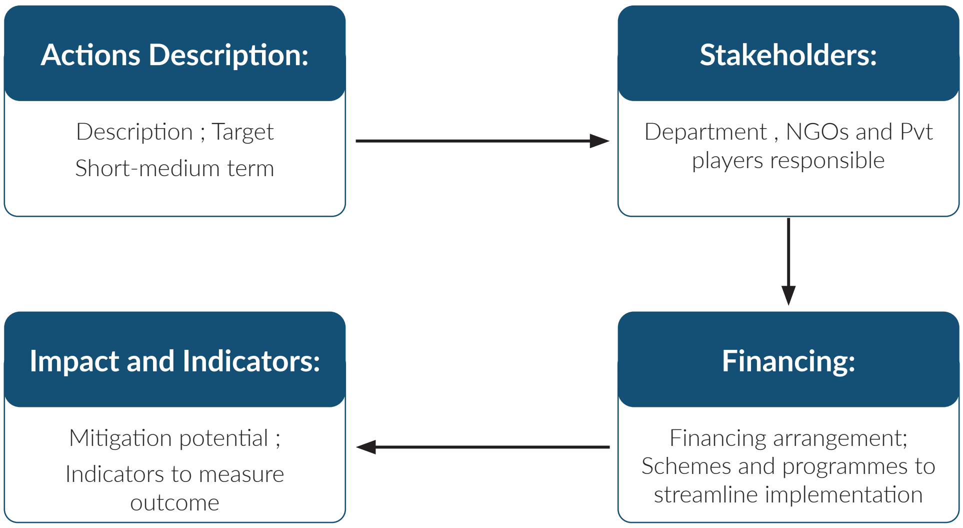


Figure 38: Flow of sectoral action plans

5.1. Power, Energy and Habitat sector: Recommended Actions

Sr.	Action Description	Stakeholders	Financing	Impact and indicators
1.	Scale up Renewable Energy (RE) generation by promoting rooftop and ground mounted installations of solar power plants (SPP) at households, institutions, government buildings, commercial buildings etc in the city. **Target** **Short-medium term** → 50% households in Jammu if installed with solar rooftop (solar potential of nearly 1000 MW) by 2030. → targets for other categories can be set accordingly	Jammu and Kashmir Energy Development Agency (JAKEDA), Jammu and Kashmir Power Development Corporation Limited, Private Institutions	Explore Public-Private-Partnerships to enable solar deployment Incentivize solar rooftop for residential/ institutional uses through additional subsidies over and above the central/state subsidies. **Schemes and programmes to streamline implementation:** Jammu Solar City initiative, National Solar Mission	**Mitigation Potential:** 113,502 t CO_2e/yr from households alone **Indicators to measure outcome:** Number of installations, capacity addition, grid independence - reduced procurement of electricity from grid

Sr.	Action Description	Stakeholders	Financing	Impact and indicators
2.	Replacing Diesel Gensets in residential/ commercial/ institutional sectors with solar powered or other RE + storage options. **Targets** **Short term** At least 40 percent of the diesel gensets existing in the city can be targeted to be shifted to RE and RE + storage-based backups by 2030. **Medium-term**, The target can be doubled, or 100% conversion can be aimed.	Jammu and Kashmir Energy Development Agency (JAKEDA)	Commercial tax incentives can be offered to existing diesel genset owners willing to make the transition. **Schemes and programmes to streamline implementation:** Jammu Solar City initiative, National Solar Policy	**Mitigation Potential:** 1.34 tCO_2e/yr for each generator replaced. Total mitigation potential can be estimated by setting a target of the number of diesels gensets to replace. **Indicators to measure outcome:** Number of diesel gensets replaced, RE capacity installed, reduction in residential/ commercial diesel consumption
3.	Encourage faster penetration of Street Lighting National Programme (SLNP) and UJALA Scheme (Domestic Efficient Lighting Program). This will ensure all lighting fixtures are replaced with energy- efficient LED bulbs, tube lights and fans at domestic, public buildings and streetlights. Awareness campaigns can encourage faster adoption. **Short Term** These interventions are short to medium terms	Energy Efficiency Services Limited (EESL); Jammu Municipal Corporation	**Schemes/Programmes to streamline implementation:** Unnat Jyoti by Affordable LEDs Street Lighting National Program (SLNP)	**Mitigation Potential:** LED bulb: 0.15 t CO_2/bulb/yr LED tubelight: 0.036 tCO_2/ tubelight/yr Fan: 0.076 tCO_2/fan/yr Total mitigation potential can be estimated by setting a target of the number of fixtures to be replaced under this scheme. **Indicators to measure outcomes:** Number of fixtures installed, number of beneficiaries, number of streetlights installed, reduction in sale of incandescent bulbs, CFL bulbs & tubelights
4.	Encouraging adoption of Energy Conservation and Sustainable Building Code (ECSBC) and Indian Green Building Council (IGBC) standards in: **Short-Medium Term** →Ensure deep electrification in residential heating, cooking uses. This will create a pathway for 'net zero energy' consumption buildings →50% of all new commercial and residential buildings with large built-up area (threshold value can be decided through consultations) **Medium-Long Term** →retrofitting existing buildings according to ECBC and IGBC standards	Jammu and Kashmir Energy Development Agency (JAKEDA), J&K Housing and Urban Development Department, ECBC	Property tax rebates/tax-waivers can be offered to IGBC/ ECSBC compliant buildings.	**Mitigation Potential:** Save 254 kg CO_2e per annum per household (Scenario: a household that consumes 6 cylinders of LPG in a year, Shifts to cooking through electricity) Net Zero Buildings can help reduce energy consumption by up to 30% annually. Data needed to estimate this potential is not available. **Indicators to measure outcomes:** number of compliant buildings, reduction in energy demand (reduced use of lighting, cooling, heating etc), reduction in LPG sales, increase in demand for electric cookstoves

5.2. Sustainable Transport: Recommended Actions

Sr.	Action Description	Stakeholders	Financing	Impact and indicators
1.	Promote wide-scale adoption of Electric Vehicles (EV) by increasing share in private passenger vehicles (cars and 2 wheelers), public transport (buses, mini-buses), intermediate public transport (3 wheelers, e-rickshaws), delivery service fleets, vehicle fleets owned by government departments etc: → establish widespread EV charging infrastructure (at strategic locations such as commercial hubs, public parking, airport, railway station etc.) →free/subsidized parking spaces, → toll-free access in selected roads **Targets** **Short Term** For segment-wise EV share,[11] the following targets can be adopted for 2030: i) 30% for E-2W. ii) 70% for E-3W, iii) 30% for E-car MoP targets to be adopted,[12] such as: i) Having at least one charging station in a grid of 3kmx3km., and ii) one charging station to be set up every 25 km on both sides of highways/roads. **Long Term** Charging infrastructure for EVs should be 100% RE powered	Jammu Municipal Corporation, Jammu Power Distribution Corporation Limited, Energy Efficiency Services Limited (EESL), J&K Housing and Urban Development Department	Additional UT level subsidies on EV adoption/ registration can be provided. Charging infrastructure could be set up through competitive bidding. Operation of charging units can thus be handed over to private entities on, say, a Build-operate-own-transfer (BOOT) model. **Schemes/ programmes to streamline implementation:** Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME II), Jammu Smart City mission	Mitigation Potential: Replacing 30% of registered cars in Jammu city can avoid 3160 t CO_2e /year For an average run of 22 km per day, 2100 kgCO_2 /year per bus can be avoided by switching to electric buses Indicators for measuring outcome: increase in sale/ registration of electric vehicles, reduction in ICE vehicle demand, reduction in fuel sales, number of charging points set up by sector (residential, commercial, institutional etc)
2.	Integrating RE for enhancing PT and IPT infrastructure such as bus depots, bus stops, hoardings near bus stops, IPT parking's etc. **Short-Medium Term** By 2030, at least 40% of power usage for the public transport infrastructure can be targeted to be sourced from RE powered systems, including battery storage options.	Jammu and Kashmir Energy Development Agency (JAKEDA), Jammu and Kashmir Transport Department, Jammu Municipal Corporation, ECSBC	Existing policies/schemes by the MNRE can be tapped into for solar powering public transport infrastructure, where applicable. **Schemes/Programmes to streamline implementation:** Jammu Solar City initiative, National Solar Mission, ECSBC	**Mitigation Potential:** Can be assessed by obtaining the current energy demand for all PT and IPT infrastructure of the city. **Indicators for measuring outcomes:** reduced grid electricity procurement, solar capacity added, number of installations/ PT and IPT infrastructure upgraded across the city.

Sr.	Action Description	Stakeholders	Financing	Impact and indicators
	A strong public transport (PT) and Intermediate Public Transport (IPT) network in the city would discourage use of private vehicles, helping curb GHG emissions and traffic congestion. Strengthening public transport (PT) and intermediate public transport (IPT) in Jammu city by improving: Short-Medium Term i) numbers: national benchmark suggests having 400-600 buses per million inhabitants, the city service level can be compared against this. ii) frequency: based on the needs of the users, the frequency of buses along various routes needs to be optimized to make PT a viable and reliable option for the public. iii) expanding network: to cover maximum area of the city under PT, decreasing interchanges iv) last-mile connectivity: IPT such as tempos, jeeps, autos can ply on routes connecting key areas to PT, to decrease use of personal vehicles to the extent possible. v) introduce low-carbon mobility (electric and other alternate fuels) for PT and IPT	Jammu and Kashmir Energy Development Agency (JAKEDA), Jammu and Kashmir Transport Department, Jammu Municipal Corporation, ECSBC	A contract model can be followed for a limited (evaluation) period by inviting Expression of Interests (EoI) from agencies interested in operating, say an EV transport fleet. FAME II scheme can be leveraged for increasing the share of Hybrid and EV buses plying in the city. **Schemes/Programmes to streamline implementation:** Jammu Smart City initiative	**Mitigation Potential:** Shift from private to public transport can save emissions by 30-40% from transport sector. Accurate mitigation potential requires passenger km traveled, current modal share and target modal share developed according to city needs. **Indicators to measure outcomes:** i) Interchanges free PT options available between two points, ii) reduced complaints/ demand for last-mile connectivity iii) improvement in local air quality iv) change in modal share focusing on decrease in registration of private vehicles
	To increase the share of non-motorized transport in Jammu city, the following measures can be undertaken: **Short-Medium Term** → Constructing dedicated cycling/ pedestrian only pathways and roads in identified locations →Removing encroachments on existing cycle pathways and footpaths →Ensuring and maintaining well-lit, clean and safe pathways for pedestrians and cyclists →Encourage e-bike/cycle hire services and mobility-as-a-service models in the city. Key locations lacking end-to-end connectivity due to which public transport ridership in the routes are low must be identified. Efforts can be laid to set up shared mobility hubs for cycle/e-bike hiring. At least 40 percent of the potential locations identified in the city can be targeted for this service implementation in the short term.	Jammu Municipal Corporation, Roads and Buildings Department	City development funds could be utilized for this purpose. Also,a proposal can be submitted to the Smart City authorities for allocation from the smart city funds. Potential public spots in the city can be identified and opened up for lease options. Agencies interested in offering shared mobility options can be selected based on the quotations submitted. **Schemes/Programmes to streamline implementation:** Jammu Smart City initiative	**Mitigation potential:** can be estimated from reduction in trips made by vehicles for short distance travel **Indicators for measuring outcomes:** length of cycle/pedestrian pathways developed, % road length covered by cycle/pedestrian pathways, increase in cycle ownership, increase in number of pedestrians, number of cycle/e-bike hiring kiosks, number of persons availing this service

[11] "ELECTRIC VEHICLE CHARGING INFRASTRUCTURE ...." https://www.niti.gov.in/sites/default/files/2021-08/HandbookforEVChargingInfrastructureImplementation081221.pdf. Accessed 6 Apr. 2023.
[12] "ELECTRIC VEHICLE CHARGING INFRASTRUCTURE ...." https://www.niti.gov.in/sites/default/files/2021-08/HandbookforEVChargingInfrastructureImplementation081221.pdf. Accessed 6 Apr. 2023.

5.3. Agriculture and Green Spaces: Recommendations Actions

Sr.	Action Description	Stakeholders	Financing	Indicators
1.	Enhancing green cover by increasing trees outside forest and green spaces through measures such as setting up of urban parks, floating gardens etc. **Short-Medium Term** →Developing urban forests through fast growing species/ techniques (Miyawaki) →Census of Trees outside Forest for estimating carbon sequestration potential →Setting up a framework to evaluate the economic benefits of ecosystems/ biodiversity.	Jammu and Kashmir Forest Department, J & K Biodiversity Council, J&K Forest Department, Department of Social Forestry	Tapping into existing funds and schemes such as CAMPA and GIM to enable plantation activities. **Schemes and Programmes to streamline actions:** CAMPA, GIM, Updated NDC targets, National Afforestation Programme, J&K Forest Policy, 2011	**Mitigation Potential:** setting a target of increasing area under forest and trees in Jammu city from 7% (11.9 km2) to 10% (17 km2) i.e. 3% increase by 2030, will contribute to sequestration of 45,342 t CO_2e per year. **Indicators:** Increase in area under urban forests, success rate of plantation activities undertaken,
2.	Promote Sustainable and Zero Budget Natural Farming by: → Use of non-chemical fertilizers → Subsidizing organic and natural fertilizers, pesticides and weedicides → Establishing agriculture market and or market links to ensure good prices for farmers producing ZBNF/organic produce. →creating awareness on sustainable and ZBNF methods	Directorate of Agriculture Production and Farmers Welfare- Jammu, Department of Horticulture, Department of Floriculture, Gardens and Parks	Fiscal incentives can be offered to farmers to transition to sustainable practices. Public Private Partnership, CSR funds can be tapped for the sustainable farming practices. **Schemes and Programmes to streamline actions:** Paramparagat Krishi Vikas Yojana (PKVY), National Mission on Sustainable Agriculture (NMSA), National Food Security Mission (NFSM), Rashtriya Krishi Vikas Yojana (RKVY)	**Mitigation Potential:** Replacing 10% of the current use of chemical fertilizers with organic fertilizers can avoid 475 tCO_2e per annum. **Indicators:** Reduction in demand of chemical fertilizers like Urea, DAP etc, increase in community composting facilities in/around agricultural lands

5.4. Waste: Recommended Actions

Sr.	Action Description	Stakeholders	Funding/Financing	Indicators
1.	Minimize landfill waste disposal by: → Promoting 'at source reduction of waste' through product reuse, extending lifetime and right to repair → Ensuring efficient and 100% segregated waste collection from across the city by distributing color coded bins at subsidized prices. → Ensure 100% recycling of recyclables through measures such as a material recycling facility (MRF), refuse derived fuel (RDF), waste to energy (W2E), etc. **Short-Medium Term** → 100 percent of segregated waste collection from the commercial segment, and at least 50 percent from the residential segment. This must go hand-in-hand with imposing penalties on i) discarding waste in the open or undesignated areas, and ii) unscientific burning of dry waste, leaves, etc through active monitoring systems. In the short-term, instances of (i) and (ii) could be reduced significantly/ eliminated. **Medium- Long Term** Recycling capacity in the city can be increased, thereby significantly minimizing the waste sent to landfill.	J&K Pollution Control Board, Jammu Municipal Corporation	Operational expenses for collection of segregated waste from households / commercial sites could be met by levying a fair fee from the beneficiaries based on the type and quantity of waste that is collected. (Example: pricing scale for quantity and organic/inorganic fraction of waste generated by households and commercial establishments) The city development / smart city funds could be utilized to set up recycling plants or recovery facilities. Revenue recovery options from processed waste such as recycled plastic, RDF etc can be explored. **Schemes / Programmes:** Solid Waste Management Rules, 2016 and Amendment 2018, Swachh Bharat Mission Urban	**Mitigation Potential:** Extensive amounts of primary data and various fractions (like % of recyclable waste, waste composition) is required to estimate the mitigation potential. Indicators: increase in % of segregated waste collection, % of waste treated, reduction in % of waste going to landfill, increase in business/initiatives in the city which utilize recycled materials, reduction in number of non-designated dumping sites across the city
2.	Establish composting facilities to prevent loss of carbon content in long route organic waste transport, The compost generated can be utilized in corporation or development authority owned parks, gardens and nurseries and also be sold as a product to generate revenue. **Short-Medium Term** Centralized composting of 100% organic waste collected **Medium-Long Term** Promoting decentralized / community level composting facilities.			**Mitigation Potential:** If 100% compostable waste is composted, the Jammu city can avoid 4,617 t CO_2e per annum. **Indicators:** increase in number of community composting facilities, reduced % of compostable waste sent to landfills,

Sr.	Action Description	Stakeholders	Funding/Financing	Indicators
3.	100% domestic wastewater treatment can be achieved through following measures: → Shift domestic wastewater treatment (STP) to aerobic set ups by having only aerobic STPs for new constructions and transitioning the old anaerobic STPs to aerobic setup. → Operation and regular maintenance of sludge removal facilities of all STPs. The sludge can be used again for the bio-methanation of compost. **Short-Medium Term** → 100% treatment of collected domestic wastewater: with 40% aerobic treatment → Build infrastructure for ensuring 100% domestic wastewater collection **Long Term** Ensure 100% wastewater collection + 100% treatment: 70% aerobic treatment and 30% anaerobic treatment with methane capture and management	J&K Pollution Control Board, Jammu Municipal Corporation, Jammu Smart Cities Limited, Jammu Development Authority, Jal Shakti Department	Encourage public- private-partnership to improve the Domestic Septage Treatment through innovative and affordable technologies. Department funds such as those allocated to Jal Shakti Department, Municipal Corporation, Development Authority and Smart Cities Mission can be utilized in addition to support from the state/central government. **Schemes:** Integrated Low-Cost Sanitation Scheme (ILCS), Swachh Bharat Mission, Atal Mission for Rejuvenation and Urban Transformation (AMRUT), Pradhan Mantri Awas Yojana (PMAY)	**Mitigation Potential:** Extensive amounts of primary data and various fractions (like degree of utilization, status of STPs, coverage of sewage system, etc) is required to estimate the mitigation potential. **Indicators:** Reduced % of wastewater being discharged to water bodies, enhancement in capture and use of methane,

CHAPTER 6

CONCLUSION

In the face of rising global temperatures and more frequent extreme weather events over recent decades, the Government of Jammu and Kashmir has intensified its focus on combatting climate change and increasing the climate resilience of the city of Jammu. City's future climate under SSP-245 scenario suggests the accumulated rainfall is projected to increase by 137 mm/yr in near future and by 208 mm/yr in far future. In SSP-585 scenario the accumulated rainfall is projected to increase by 209 mm/yr and 516 mm/yr in near and far future respectively. Under SSP-245 scenario in near future the maximum and minimum temperature is projected to increase by 0.97°C and 1.41°C respectively. In far future, under SSP-245 scenario the maximum and minimum temperature is going to increase by 2.21°C and 1.99°C respectively. Under SSP-585 scenario in near-future the maximum and minimum temperature are projected to increase by 1.10°C and 1.61°C respectively while as the upsurge is on higher end by 3.97°C and 4.62° C in far-future. This will result in more pronounce urban and fluvial flooding, heat stress, increase landslides, forest fires and drought.

The Department of Ecology, Environment and Remote Sensing, Government of Jammu and Kashmir, in association with the United Nations Development Programme (UNDP) have prepared this Climate Resilient City Action Plan (CRCAP) for Jammu City. The initiative to develop CRCAP's in India started in 2009 as a part of the National Action Plan on Climate Change (NAPCC). The Government of India launched the NAPCC to address climate change issues in various sectors such as agriculture, forestry, and energy. Under the NAPCC, the Ministry of Environment, Forest, and Climate Change (MoEFCC) developed guidelines for preparing CRCAP's in urban areas. The CRCAP is a roadmap outlining the city's mitigation-adaptation strategies and actions to tackle this pressing global and local crisis. The CRCAP aids the local government of Jammu City in estimating greenhouse gas emissions, identifying vulnerability hotspots, understanding critical infrastructure systems with respect to resilience, and developing specific climate change mitigation and adaptation plans while promoting sustainable development. The CRCAP builds on policies and plans developed at city, and ward levels with the goals at global (SDGs) level. The CRCAP- Jammu envisions a city where its communities and citizens are safer, healthier, and thrive even in a changing and uncertain climate. The CRCAP is committed to a net zero and climate-resilient Jammu by 2050. This means ensuring just transitions – towards net zero pathways; significant investments– towards inclusive and transformative climate solutions; and coordinated and robust governance – to ensure a targets-based approach.

The city of Jammu is regarded as a multi-hazard-prone area, considering its vulnerability to floods, urban heat island effects, earthquakes, landslides, and forest fires. The analysis showed 15.55 sq. km. (12.26%) of areas is exposed with floods and assets exposed are 7.1% of substations and 9.7% of transformers (power sector), 7.4% of mobile towers (telecommunication sector), 5.8% of sewerage network, 8.4% of road network is exposed to floods. Other critical infrastructures such as health, schools, water, solid waste management, and fire stations (the assets at risk are plotted on maps) were prone to such risks. A relative ward-level assessment was also performed wherein various indexes were analyzed to bring to light the differential in vulnerability witnessed across all the wards. Based on the aforementioned analysis, the composite vulnerability assessment deduced the highly vulnerability Wards as 32 and 71, with the total population accounting to 4.53% and Wards 19, 39, and 65 are medium vulnerable with a population of about 5.30%. In an attempt to tackle these vulnerabilities, adaptive measures need to be undertaken, wherein vulnerable locations are identified and integrated with future growth strategies to facilitate a low impact development in these locations. While doing so, we aim to ensure minimum exposure to the people and community, making them less vulnerable to climate-induced risks.

In light of the forecasted scenarios concerning the climatic trends and GHG emissions trends, proactive adaptation strategies combined with extensive in-depth vulnerability assessments were undertaken to help curb extreme weather events' impacts. GHG emissions trends, pro-active adaptation strategies in amalgamation with extensive in-depth vulnerability assessments to help in curbing the impacts of extreme weather events were undertaken. To accomplish the same, energy sector emissions were estimated for fuel combustion from transport, industries, agriculture, commercial, and residential categories. It was found that emissions from the energy sector increased at a CAGR of ~3% from 419.76 kt CO_2e in 2005 to 629.16 kt CO_2e in 2019. The energy emissions of Jammu city accounted for ~69% of the economy-wide emissions in 2019. Within the energy sector, it was found that transport category was the major contributor to the GHG emissions with a share of ~75% in 2019. This was followed by agriculture and industrial energy categories with shares of ~13% and ~6%, respectively. In light of the analysis, it was realized that the GHG emissions of Jammu city decreased from 1062.83 kt of CO_2 equivalent (kt CO_2e) in 2005 to 915.58 kt CO_2e in 2019 at a CAGR of ~1%. While energy emissions steadily increased, economy-wide emissions reduced due to reduction in emissions from agriculture, forestry, and other land-use (AFOLU) sector. Within the energy sector, transport is the highest contributing category with its emissions progressively increasing, while the contribution of other categories to energy emissions

remained more or less constant. The spike of 2012 in the economy-wide category is due to increase in AFOLU emissions. Emissions from the waste sector marginally increased during the reference period from 39.81 kt CO_2e in 2005 to 55.29 kt CO_2e in 2019.

In order to mitigate GHG emission and reduce the climate risks, by 2050, the city aims to achieve its overarching goals of being carbon-neutral, through net-zero emissions and resilience in line with the Paris Agreement and Sustainable Development Goals (SDGs). The climate-resilient action plan is drafted. The sectoral action plan focuses on power, energy and habitat sector, sustainable transport, agriculture and green spaces and waste management. The resilience interventions included in the action plan are informed by the baseline sectoral GHG emissions and identified climate vulnerabilities.

The power, energy and habitat has approx. mitigation potential of 113,502 t CO_2e /yr from households, 1.34 t CO_2e /yr for each generator replaced, LED bulb: 0.15 t CO_2/bulb/yr ; LED tubelight: 0.036 tCO_2/tubelight/yr; Fan: 0.076 tCO_2/fan/yr. Save 254 kg CO_2e per annum per household (Scenario: a household that consumes 6 cylinders of LPG in a year, Shifts to cooking through electricity). The sustainable transport has approx. mitigation potential of Replacing 30% of registered cars in Jammu city can avoid 3160 t CO_2e /year; For an average run of 22 km per day, 2100 kgCO_2 /year per bus can be avoided by switching to electric buses; Shift from private to public transport can save emissions by 30-40% from transport sector. Accurate mitigation potential requires passenger km travelled, current modal share and target modal share developed according to city needs; The agriculture and green spaces has mitigation potential with increasing area under forest and trees in Jammu city 45,342 t CO_2e under forest and trees; Replacing 10% of the current use of chemical fertilizers with organic fertilizers can avoid 475 t CO_2e per annum. In the solid waste sector 100% compostable waste is composted, the Jammu city can avoid 4,617 t CO_2e per annum.

The success of CRCAP is dependent on the residents of Jammu and their willingness to adopt sustainable choices in their daily lives to help achieve several CRCAP targets. The government/ municipality, civil society groups and private investors are encouraged to participate, deliberate, and catalyse the success of Jammu's first-ever climate-resilient action plan.

CHAPTER

7 REFERENCES

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CHAPTER
8 ANNEXURES

8.1. Glossary

AFOLU: Agriculture, Forest and Other Land Use

Biological Oxygen Demand (B.O.D.): The amount of oxygen required by bacteria in decomposing organic matter under aerobic condition at 20°C for 5 days or 27°C for 3 days

CAGR: Compound Annual Growth Rate is calculated by the taking the nth root of the years in the period being considered

Carbon Dioxide or CO_2: A naturally occurring greenhouse gas. It is also emitted by combustion of fossil fuels and biomass, as well as land use changes and other industrial processes. Other GHGs are measured with reference to CO_2 , and therefore CO_2 has a Global Warming Potential of 1.

CO_2 Equivalent: It is the sum total of all Greenhouse Gases in terms of their global warming potential. In this document the CO equivalent includes the sum of Carbon dioxide, Methane multiplied by its GWP (21) and Nitrous oxide multiplied by its GWP (310)

Country Specific data (CS): Data for either activities or emissions that are based on research carried out on-site either in a country or in a representative country

Default (D): Default emission factor/value as listed in IPCC

Decomposition: Decomposition or rotting is the process by which tissues of a dead organism break down into simpler forms of matter

Degradable Organic Carbon (DOC): It is the carbon content of paper and textiles; garden-park waste and other(non-food) putrescibles; food waste; and other organic biodegradable waste

Emission Factor: A coefficient that quantifies the emissions or removals of a gas per unit activity. Emission factor are often based on a sample of measurement data averaged to develop a representative rate of emission for a given activity level under a given set of operating conditions

Emissions: The release of greenhouse gases and/or their precursors into the atmosphere over a specified area and a period of time

Emission Intensity: Emission intensity is the average emission rate of a given pollutant from a given source relative to the intensity of a specific activity ; for example grams of carbon dioxide released per mega joule of energy produced, or the ratio of greenhouse gas emissions produced to GDP or total population

Energy: This category includes all GHG emissions arising from combustion of fossil fuel and fugitive release of GHGs. Emissions from the non-energy use are not included here and are reported under the industry sector

Enteric Fermentation: Methane is emitted as a by-product of the normal livestock digestive process, in which microbes resident in the animal's digestive system ferment the feed consumed by the animal.

Greenhouse Gases: Greenhouse gases are gases in an atmosphere that absorb and emit radiation within the thermal infrared range

Global temperature potential (GTP): The ratio between the global mean surface temperature change at a given future time horizon (TH) following an emission (pulse or sustained) of a compound *x* relative to a reference gas *r* (e.g., CO_2)

Global warming potential (GWP): The ratio of the time-integrated radiative forcing from the instantaneous release of 1 kg of a trace substance relative to that of 1 kg of a reference gas (IPCC, I990)

Key Categories: This concept is used to identify the categories that have a significant influence on a region's total inventory of greenhouse gases in terms of the absolute level of emissions and removals, the trend in emissions and removals, or uncertainty in emissions and removals

Landfill: A method for final disposal of solid waste on land. The refuse is spread and compacted and a cover of soil applied so that effects on the environment (including public health and safety) are minimized

Manure: The term 'manure' is used collectively to include both dung and urine (i.e., the solids and the liquids) produced by livestock

Net Emissions: A total of GHG emissions from source categories adjusted by/including removals by sinks

Nitrous Oxide or NO_2: One of the six greenhouse gases to be mitigated under the Kyoto Protocol. Its emission is mainly caused by burning fossil fuels and manufacturing of fertilizer. It has a Global Warming Potential of 310 times that of CO_2.

Removals: Removal of greenhouse gases and or their precursors from the atmosphere by a sink

Tiers: A tier represents a level of methodological complexity. The Tier 1 method involves using default emissions factors or use of country specific emission factors with activity data which has been derived, while the Tier 2 method involves using country-specific information to calculate the emissions factors.

8.2. Energy sector methodology

1. 1A Fuel Combustion

1.1. 1A3 Transport

A. Category description

Transport sector emissions are reported under four different modes: road transportation, railways, civil aviation, and water-borne navigation. For Jammu city, only road transport emissions have been accounted for in this exercise. Emissions from various fuels (diesel and petrol) have been estimated separately.

B. Methodology

To calculate emissions from the transport sector, the 2019 Refinement to the IPCC 2006 **Guidelines for National Greenhouse Gas Inventories** was used. According to this, emissions are a product of the activity data of fuel type and its corresponding emission factor, as represented in Equation 1. Table 13 presents the emission factors used. The calorific value and density of fuels have been sourced from the Indian Network on Climate Change Assessment (INCCA) (MoEFCC, 2010) and from the Ministry of Petroleum and Natural Gas (MoPNG, 2017).

$$Emissions_{Gas} = Activity\ Data_{Fuel}\ X\ NCV_{Fuel}\ X\ Emission\ Factor_{Gas} \qquad \text{[Equation 1]}$$

The methodology for estimating emissions from the energy sector is consistent with a Tier I approaches specified by IPCC. Similarly, for calculating the CH_4 and N_2O emissions, the same equations for each fuel have been considered.

Step 1: Emission Factor

The emission factors for CO_2 and the specific emission factors with respect to road transportation for CH_4 and N_2O are given in detail in the table 11:

Table 13: Net Calorific Values and Emission Factors used in the transport sector

Fuel type	Net Calorific Value (NCV) & CO_2 Emission Factor (MoEFCC, 2010)		Emission Factors - Road Transportation (IPCC, 2006)	
	NCV	CO_2 EF	CH_4 EF	N_2O EF
	TJ/kt	t/TJ	kg/TJ	kg/TJ
Diesel	43.00	74.10	3.90	3.90
Gasoline/Motor Spirit	44.30	69.30	33.00	3.20

Step 2: Emission Estimation

- Total fuel consumed in Jammu city was obtained from the Comprehensive Mobility Plan (2020) for the years 2015-2019. For 2005 to 2014, the fuel consumption was estimated using CAGR.
- The share of diesel consumed in road transport was obtained from the PPAC, findings from Nielsen study (PPAC, 2013) - 63.3% was applied to the total diesel consumed in the city.

- The share of petrol consumed in road transport was also obtained from the PPAC, findings from Nielsen study (PPAC, 2013) - 100% was applied to the total petrol consumed.
- Emissions from fuel consumption were estimated using Equation 1 and added for each fuel.

1.2. 1A4 Other sectors

A. Category description

Other sectors include energy consuming activities in residential, commercial, and agricultural sectors. The activity data for this sector represents the fuel consumption used for specific applications such as cooking, lighting, heating, use of small (< 1 MW) Diesel Generator (DG) sets, drying of field produce, operation of tractors, diesel pump-sets, and other farm implements.

Tier I approach was applied for emission calculations in this sub-sector.

B. Methodology

The main source of activity data was Jammu city Comprehensive Mobility Plan (2020), which gave the total annual fuel consumed in the city. The fuel types covered in this analysis include diesel, petrol and LPG.

8A4a Residential Sector

- The fuels considered under the residential sector are LPG, and diesel.
- Fuel consumption in diesel sets was estimated based on data obtained from the PPAC, findings from Nielsen study (PPAC, 2013) – 3.35% applied to the total diesel consumed in the city.
- The share of LPG fuel consumption in Residential sub-sector was obtained based on GHG Platform India estimations for the erstwhile state of Jammu and Kashmir (GHGPI, 2022) – 97% applied to the total LPG consumed in the city.

1A4b Commercial Sector

- Diesel annual activity data was calculated using data on total diesel consumption, which was obtained from Jammu city Comprehensive Mobility Plan (2020).
- The diesel consumption (commercial) was calculated from the information in PPAC's Nielsen report (PPAC, 2013). A weighted average of zonal share was used – 1.82% on the total diesel consumption in the city.
- The share of LPG fuel consumption in Commercial sub-sector was obtained based on GHG Platform India estimations for the erstwhile state of Jammu and Kashmir (GHGPI, 2022) – 3% applied to the total LPG consumed in the city.

1A4c Agriculture

Diesel (HSDO and LDO)

- According to the study conducted by Nielson for PPAC, the share of diesel consumed by tractors, agricultural pump sets and implements was 21.96% (Nielsen, 2013). This percentage share of diesel (retails) consumed in the agriculture sector was used to calculate the total diesel consumed in the agriculture sub-sector in Jammu city.

8.3. AFOLU sector methodology

1. 3A Livestock

1.1. 3A1 Enteric Fermentation

1.1.1 Category description

Enteric Fermentation, resulting in emissions of CH_4, arises out of the process of ingesting and digesting of food eaten by herbivores, primarily bovines and ovine. However, other animals such as camels, horses and mules etc. also emit small amounts of CH_4.

Methane emissions from Enteric Fermentation have been calculated using methodology prescribed in 2019 IPCC Refinement to 2006 IPCC Guidelines for National GHG Inventories. CO_2 emissions from livestock are not estimated because annual net CO_2 emissions are assumed to be zero – the CO_2 photosynthesized by plants is returned to the atmosphere as respired CO_2 (Chapter 10, Volume 4, IPCC 2019). Similarly, as no nitrogen is released during the process of digestion in livestock, no nitrous oxide (N_2O) emissions are reported.

1.1.2. Methodology

Tier II methodology has been used for major methane emitting categories (i.e. bovines) and Tier I methodology has been used where country specific emission factors were not available.

The following steps were performed for emission estimation from enteric fermentation:

Step 1: Emission Factor

Methane emission factors for the livestock categories have been sourced from NATCOM II and IPCC 2019. Table 14 below provides emission factors for each sub-group:

Table 14: Emission factor of each sub-group in terms of kilograms of methane per animal per year

Category	Sub-category	Age group	Methane emission factor ($kgCH_4$/head/year)	Source
Indigenous Cattle	Dairy cattle	Indigenous	28.00	NATCOM II
	Non-dairy cattle (indigenous)	year	9.00	NATCOM II
		1-3 year	23.00	NATCOM II
		Adult	32.00	NATCOM II
Cross-bred cattle	Dairy cattle	Cross-bred	43.00	NATCOM II
	Non-dairy cattle (cross-bred)	0-1 year	11.00	NATCOM II
		1-3 year	26.00	NATCOM II
		Adult	33.00	NATCOM II
Buffalo	Dairy buffalo		50.00	NATCOM II
	Non-dairy buffalo	0-1 year	8.00	NATCOM II
		1-3 year	22.00	NATCOM II
		Adult	44.00	NATCOM II
Horses & Ponies			18.00	IPCC
Pigs			1.00	IPCC
Poultry			0.00	IPCC

Step 2: Emission Estimation

Emissions from the process of enteric fermentation are calculated by multiplying the selected emissions factors with the associated animal population (IPCC equation 10.19) and summed using IPCC equation 10.20 given below:

$$Emissions = EF_{(T)} \cdot \left(\frac{N_{(T)}}{10^6}\right)$$

Where,

Emissions = methane emissions from Enteric Fermentation, Gg CH_4 yr^{-1}

$EF_{(T)}$ = emission factor for the defined livestock population, kg CH_4 $head^{-1}$ yr^{-1}

$N_{(T)}$ = the number of head of livestock species/category T in the country

T = species/category of livestock

$$Total\ CH_{4_{Enteric}} = \sum_i E_i$$

Where,

Total $CH_{4Enteric}$ = total methane emissions from Enteric Fermentation, Gg CH_4 yr^{-1}

E_i = Emissions for the i^{th} livestock categories and subcategories

1.2. Manure Management

1.2.1 Category description

Manure management emissions arise from the process of animal manure decomposition. In general, emissions vary depending on the type of decomposition – aerobic or anaerobic. If manure is decomposed naturally i.e., aerobically, little or no emissions are produced. However, if manure is treated anaerobically, higher emissions are observed.

Manure management results in CH_4 and N_2O emissions. CO_2 emissions from livestock are not estimated because annual net CO_2 emissions are assumed to be zero – the CO_2 photosynthesized by plants is returned to the atmosphere as respired CO_2 (Chapter 10, Volume 4, IPCC 2019).

1.2.2. Methodology

Methane emissions from manure management have been calculated using the methodology provided in the 2019 IPCC Refinement to 2006 IPCC Guidelines for National GHG Inventories.

The following steps were performed for estimating **CH_4 emission** due to manure management:

Step 1: Emission Factor Estimation

Methane emission factors for the livestock categories have been sourced from NATCOM II and IPCC 2019. The Table 15 mentioned below provides emission factors for each sub-group:

Table 15: Emission factor of each sub-group in terms of kilograms of methane per animal per year

Category	Sub-category	Age group	Methane emission factor ($kgCH_4$/head/year)	Source
Indigenous Cattle	Dairy cattle	Indigenous	3.50	NATCOM II
	Non-dairy cattle (indigenous)	year	1.20	NATCOM II
		1-3 year	2.80	NATCOM II
		Adult	2.90	NATCOM II
Cross-bred cattle	Dairy cattle	Cross-bred	3.80	NATCOM II
	Non-dairy cattle (cross-bred)	0-1 year	1.10	NATCOM II
		1-3 year	2.30	NATCOM II
		Adult	2.50	NATCOM II
Buffalo	Dairy buffalo		4.40	NATCOM II
	Non-dairy buffalo	0-1 year	1.80	NATCOM II
		1-3 year	3.40	NATCOM II
		Adult	4.00	NATCOM II
Horses & Ponies			2.19	IPCC
Pigs			4.00	IPCC
Poultry			0.00	IPCC

Step 2: Emissions Estimation

Emissions from the process of manure management are calculated by multiplying the selected emissions factors with the associated animal population (IPCC equation 10.22) as given below:

$$CH_{4_{Manure}} = \sum_{(T)} \frac{\left(EF_{(T)} \cdot N_{(T)}\right)}{10^6}$$

Where,

$CH_{4Manure}$ = methane emissions from Manure Management, Gg CH_4 yr^{-1}

$EF_{(T)}$ = emission factor for the defined livestock population, kg CH_4 head-1 yr^{-1}

$N_{(T)}$ = the number of head of livestock species/category T in the country

T = species/category of livestock

Step 3: Emissions from all livestock categories are added to get total methane emissions from manure management.

The following steps were performed for estimating **N_2O emission** due to manure management:

Step 1: Emission Factor

For calculating nitrogen excretion, IPCC values[13] were used for estimating nitrogen excretion, per animal. The values adopted were:

Dairy cattle - 60 kg N/ animal/ year

Non-dairy cattle - 40 kg N/ animal/ year

Pigs - 16 kg N/ animal/ year

Poultry - 0.6 kg N/ animal/ year

The following nitrogen emission factors were used as per IPCC:

Table 16: Nitrogen Emission Factors

Category of Livestock	Nitrogen emissions per animal (kg N_2O/head/year)
Dairy cattle	0.0006
Non-dairy cattle	0.0004
Pigs	0.0074
Poultry	0.0025

Step 2: Emissions Estimation

Total emissions were determined by multiplying the number of animals in each category with emission factor. Nitrogen emissions from manure management were calculated using the equation in step 3.

N_2O emissions were calculated in the following manner:

IPCC equation 10.25[14] that was used was the following:

$$N_2O_{animals} = N_2O_{AWMS} = \sum\left[N_T \cdot N_{ex(T)} \cdot AWMS_T \cdot EF_{3(AWMS)}\right] \cdot \frac{44}{28}$$

Where,

$N_2O_{animals}$ = N_2O emissions from animal production in a country (kg N/yr)

$N_2O_{AW\ MS}$ = N_2O emissions from Animal Waste Management System in the country (kg N/yr);

N_T = number of animals of type T in the country

$N_{ex(T)}$ = N excretion of animals of type T in the country (kg N/animal/yr)

$AWMS_T$ = fraction of $N_{ex(T)}$ that is managed in one of the different distinguished animal waste management systems for animals of type T in the country

$EF_{3(AWMS)}$ = N_2O emission factor for an AWMS (kg N_2O -N/ kg of in AWMS)

T = type of animal category

44/28 = conversion of (N_2O-N) emissions to N_2O emissions

Step 3: Emissions from all categories are aggregated and total emission expressed as Gg N2O/ year.

Emissions (Gg/ Year) = EF (kg/ head/ year) x population/ 10^6 kg/ Gg.

2. 3B Land

In this section, the category descriptions and the common methodology applied to estimate emissions from the following land use categories has been described

2.1 Category descriptions

2.1.1. 3B1 Forestland

Emissions originate from Forestland due to changes in biomass, dead organic matter and soil organic matter on Forest Land and Land converted to Forest Land. For GHG estimation from Forestland in India, the Stock-Difference Method is applied along with country specific estimates of activity data and emission factors, in-line with the choice of method in Volume 4, Chapter 4, 2019 IPCC Guidelines.

[13] IPCC 2006 Guidelines, Chapter 10, Table 10.19, summarized from IPCC 1996 Guidelines, Chapter 4, Table B1, http://www.ipcc-nggip.iges.or.jp/public/gl/guidelin/ch4ref8.pdf

2.1.2. 3B2Cropland

Cropland includes arable and tillable land, rice fields and agroforestry systems where the vegetation structure falls below thresholds used for Forest Land. The amount of carbon stored in and emitted or removed from permanent cropland depends on crop type, management practices and soil & climate variable. Annual crops (cereals, vegetable) are harvested each year, so there is no long-term storage of carbon in biomass and hence, not accounted. GHGs from Cropland are estimated from perennial woody vegetation in orchards, vineyards and agroforestry systems and soil. Carbon stored in biomass, depends on species type and cultivar, density, growth rates, harvesting and pruning practices (Volume 4, Chapter 5, 2019 Refinement to the 2006 IPCC Guidelines for National GHG Inventories).

2.1.3. 3B5 Settlements

Settlements are defined as including all developed land i.e., residential, transportation, commercial, and production (commercial, manufacturing) infrastructure of any size, unless it is already included under other land-use categories. The land-use category Settlements includes soils, herbaceous perennial vegetation such as turf grass and garden plants, trees in rural settlements, homestead gardens and urban areas. Soils and DOM in Settlements may be sources or sinks of CO_2, depending on previous land use, topsoil burial or removal during development, current management, particularly with respect to nutrient and water applications, and amount of vegetation cover spread among roads, buildings and associated infrastructure (Volume 4, Chapter 8, 2019 Refinement to 2006 IPCC Guidelines for National GHG Inventories).

2.1.4. 3B6 Other Lands

The sub-category 'other lands' includes wasteland, snow covered area, rocky surfaces, water bodies, etc.

Methodology

Inter-annual climatic variability is a crucial factor for consideration when estimating emissions from Land sub-sector. Substantial changes in standing biomass can occur from year to year that is associated with differences in annual rainfall or water availability. Inter-annual rainfall variability may also affect land management decisions such as irrigation or fertilizer application (Volume 4, Chapter 5, 2006 IPCC Guidelines for national GHG inventories) and thereby affecting emission estimates.

Steps followed

Step 1:

Emission estimation for various categories under Land sub-sector is done by categorizing land in two categories viz., Land Remaining Land and Land Converted to other Land Use. This study uses the 2019 Refinement to the 2006 IPCC Guidelines for National GHG Inventories to estimate emissions from these categories. The steps followed in the estimation process for both the categories remain same with the only difference arising in choice/estimation of emission factors

The activity data, in the form of Land Use Change matrices for the years 2000 to 2014 was obtained from Sharma and Kaur (2016).

Step 2:

Change in Biomass Carbon stock in Land: Carbon stock change in Land remaining Land is estimated by taking the biomass change factor derived from BUR III (0.045 tC/ha/yr).

[14] http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_10_Ch10_Livestock.pdf - page 10.53

Step 3:

Change in Soil Organic Carbon content in Land: Land is typically converted to other land use, for example forest land is diverted to cropland, or cropland diverted to settlements etc. Regardless of soil type (i.e., mineral or organic), the conversion of land to other land use will, in most cases, result in a gain or loss of soil C for some years following conversion (*Chapter 5*, *Volume 4*, 2019 Refinement to the 2006 IPCC Guidelines for National GHG Inventories*)*.

For land use change, the rate of change of SOC and the stock change factors has been derived from multiple studies as seen in table 15.

Table 17: Soil organic carbon stock and stock change factors for various land use types

Land Use Type	SOC_{ref} (t C/ha)	Source	Stock change factors (F_{LU}; F_{MG}; F_I)	Source
Forestland	145.91	M Kaul et al., 2009[15]	1.00; 0.96; 1.00	M Kaul et al., 2009
Cropland	102.90	K. Sreenivas et al., 2016[16]	0.64; 1.00; 0.94	IPCC
Settlement	19.70	K. Sreenivas et al., 2016	0.88; 1.16; 1.00	IPCC
Other land	19.07	K. Sreenivas et al., 2016	1.00; 1.00; 1.00	IPCC

Further, the total change in soil C stocks for Land converted to other Land Use is estimated using Equation 2.25, Chapter 2, Volume 4 of the 2019 Refinement to 2006 IPCC Guidelines for National GHG Inventories given below:

$$\Delta C_{mineral} = \frac{\left(SOC_0 - SOC_{(0-T)}\right)}{D}$$

$$SOC = \sum_{C,S,I} SOC_{REF_{C,S,I}} \cdot F_{LU_{C,S,I}} \cdot F_{MG_{C,S,I}} \cdot F_{I_{C,S,I}} \cdot A_{C,S,I}$$

where,

$\Delta C_{mineral}$ = annual change in carbon stocks in mineral soils, tonnes C yr^{-1}

SOC_0 = soil organic carbon stock in the last year of an inventory time, tonnes C

$SOC_{(0-T)}$ = soil organic carbon stock at the beginning of the inventory time, tonnes C

SOC_0 and $SOC_{(0-T)}$ are calculated using the SOC equation in the box where the reference carbon stocks and stock change factors are assigned according to the land-use and management activities and corresponding areas at each of the points in time (time = 0 and time = 0-T)

D = Time Dependence, 20 years

C = represents the climate zones, S the soil types, and I the set of management systems that are present in a country.

SOC_{REF} = the reference carbon stock, tonnes C ha^{-1}

F_{LU} = stock change factor for land-use systems or sub-system for a particular land-use, dimensionless

F_{MG} = stock change factor for management regime, dimensionless

F_i = stock change factor for input of organic matter, dimensionless

A = land area of the stratum being estimated, ha. All land in the stratum should have common biophysical conditions (i.e., climate and soil type) and management history over the inventory time to be treated together for analytical purposes

15 M. Kaul, V.K. Dadhwal, G.M.J. Mohren. Land use change and net C flux in India forests. Forest Ecology and Management 258 (2009) 100–108; http://frienvis.nic.in/writereaddata/UploadedFile/ENVIS_634776204210918768_Forest%20Ecology%20and%20Management.pdf

16 Kandrika Sreenivas, V.K. Dadhwal, Suresh Kumar, G. Sri Harsha, Tarik Mitran, G. Sujatha, G. Janaki Rama Suresh, M.A. Fyzee, T. Ravisankar,Digital mapping of soil organic and inorganic carbon status in India, Geoderma, Volume 269, 2016, Pages 160-173, ISSN 0016-7061,https://nrsc.gov.in/Digital_mapping_of_soil_organic_and_inorganic_carbon_status_in_India

Step 4:

The total biomass and soil organic carbon content for each sub-category is calculated by multiplying the area within that sub-category with the respective change in biomass and soil organic carbon for that particular sub-category. The total change in carbon stocks is calculated by adding up all values of the sub-categories estimates.

3. 3C Aggregate Sources and Non-CO_2 Emission Sources on Land

Estimation of Emissions from Agricultural Soils, including from: 3C4 Direct N_2O emissions from managed soils and 3C5 Indirect N_2O emissions from Managed Soils

3.1. Category description

A portion of nitrogenous fertilisers applied in agricultural soils are lost into the atmosphere through direct emissions of N_2O through nitrification and denitrification. In addition, there are also indirect emissions of N_2O through volatilization losses, leaching and runoffs.

3.2. Methodology

Step 1:

Data on total N consumption for years 2007-08 to 2014-15 in the erstwhile J&K state was taken from Directorate of Economics and Statistics, Department of Agriculture, Cooperation and Farmers Welfare, Ministry of Agriculture and Farmers Welfare, Govt of India. For year 2004-05 to 2006-07 and 2015-16 the interpolation and extrapolation techniques were used using the CAGR of the above-mentioned period. The month wise data in the erstwhile J&K state on the actual sale[17] of urea was obtained from the annual report 'Indian Fertilizer Scenario' published by the Department of Fertilizers, Ministry of Chemicals and Fertilizers Government of India which was then added up to obtain the annual sales. For calculating the quantity of Nitrogen in Urea, the total urea consumption was multiplied by 46 percent as urea contains 46% Nitrogen[18]. So, N consumed by other fertilizers was found by subtracting the N consumed in urea from the total N consumption.

Step 2:

A factor for the fertilizer used per unit agriculture area in the state was derived for each year of the study period. This factor was then applied to the city-level agriculture area to estimate total N consumption in Jammu city.

Step 3:

For the calculation of the nitrogen loss from volatilization of NH_3 and NO_x, a magnitude of 15 percent per kg of urea and other fertilizers was considered instead of IPCC fraction of 10 percent as most Indian soils are low in acidity and high in average temperature therefore resulting in more volatilization losses. The fraction of N lost through leaching is 10 percent of N applied to the soil. It should be noted that the above-mentioned factors have been sourced from BUR-II[19].

Step 4:

The default IPCC emission factor for N_2O emission for atmospheric NH_3 and NO_x is 1 percent; however, considering characteristics of Indian soils, 0.5 percent emission factor was used for N_2O from volatilized N. Similarly, emission factor used for deposited N from leaching and runoff was 0.5 percent as stated in BUR-II[20].

8.4. Waste Sector Methodology

1.4A Solid Waste Disposal

1.1. 4A2 Unmanaged Waste Disposal Sites

A. Category Description

When solid waste is disposed of in landfills or in dumpsites and in the presence of anaerobic conditions, methanogenic bacteria break-down the degradable organic component in the waste, releasing CH_4 emissions. Decomposition of the organic content occurs slowly and the CH_4 emissions from a given mass of solid waste deposited continue to be released over a time period spanning a few decades.

This assessment covers the disposal of municipal solid waste in the city of Jammu. Municipal solid waste is generally defined as waste collected by local municipal governments or other local authorities, typically including residential, commercial and institutional waste, street sweepings, and garden and park waste in either solid or semi-solid form (excluding industrial, hazardous, bio- medical and e-waste). Industrial waste and other waste such as clinical waste and hazardous waste are not considered in the emission estimation, given the lack of reliable information for these waste streams and in accordance with India's Second National Communication and BUR reports.

B. Methodology

Tier 1 estimation methodology was used for this sub-sector following the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

The urban population of Jammu city was sourced from Framework Document for Jammu city Climate Action Plan. This population was used to project population estimates for the years 1951 to 2019.

The following equations were used to estimate emissions due to solid waste in Jammu city.

CH_4 EMISSION FROM SOLID WASTE DISPOSAL SITES

$CH_4\ Emissions = [\square\ CH_4\ generatedT - R_T] * (1 - OX_T)$

Where,

CH_4 Emissions = CH_4 emitted in year T, Gg

T = inventory year

X = waste category or type/material

RT = recovered CH_4 in year T, Gg (default value of 0, IPCC)

OX_T = oxidation factor in year T, (fraction) (default value of 0, IPCC)

The amount of CH_4 formed from decomposable material is found by multiplying the CH_4 fraction in generated landfill gas and the CH_4 /C molecular weight ratio (16/12).

CH_4 GENERATED FROM DECAYED DDOCm

$CH_4\ generated_T = DDOCm_{decompT} * F * 16/12$

Where,

$CH_4 generated_T$ = amount of CH_4 generated from decomposable material

$DDOCm,_{decompT}$ = Decomposable Degradable Organic Carbon (DDOCm) decomposed in year T, Gg

[18] Refer Table 5 http://fert.nic.in/sites/default/files/Full%20Book.pdf
[19] Refer Table 2.11 https://unfccc.int/sites/default/files/resource/INDIA%20SECOND%20BUR%20High%20Res.pdf
[20] Refer Table 2.11 https://unfccc.int/sites/default/files/resource/INDIA%20SECOND%20BUR%20High%20Res.pdf

F = fraction of CH_4, by volume, in generated landfill gas (fraction) (default value of 0.5) (IPCC)

16/12 = molecular weight ratio CH_4/C (ratio)

The basis for the calculation is the amount of DDOCm. DDOCm is the part of the organic carbon that will degrade under the anaerobic conditions in the solid waste disposal site.

It equals the product of the mass of waste deposited (W) for the city, the fraction of degradable organic carbon in the waste (DOC), the fraction of the degradable organic carbon that decomposes under anaerobic conditions (DOCf), and the part of the waste that will decompose under aerobic conditions (prior to the conditions becoming anaerobic) in the solid waste disposal site, which is interpreted with the methane correction factor (MCF).

DECOMPOSABLE DOC FROM WASTE DISPOSAL DATA

$DDOC_m = W * DOC * DOC_f * MCF$

Where,

$DDOC_m$ = mass of decomposable DOC deposited,

Gg W = mass of waste deposited for the state, Gg

DOC = degradable organic carbon for the respective state in the year of deposition, fraction, Gg C/Gg waste

DOC_f = fraction of DOC that can decompose (fraction) (Default value of 0.5) (IPCC)

MCF = CH_4 correction factor for aerobic decomposition in the year of deposition (fraction) (default value of 0.4) (IPCC)

The DOC in bulk waste is estimated based on the composition of waste and can be calculated from a weighted average of the degradable carbon content of various components (waste types/material) of the waste stream. The following equation estimates DOC using default carbon content values:

ESTIMATED DOC USING DEFAULT CARBON CONTENT VALUES

$DOC = \Sigma(DOCi * Wi)i$

Where,

DOC = fraction of degradable organic carbon in bulk waste,

Gg C/Gg waste DOCi = fraction of degradable organic carbon in waste type i

Wi = fraction of waste type i by waste category

The default DOC values for various fractions in MSW are given in the table 16. Since plastics, glass and metals do not contain degradable organic carbon they have DOC value as zero.

Table 18: Default DOC content of different MSW components

MSW component	DOC content in % of wet waste	DOC content in % of dry waste
Paper/cardboard	40	44
Textiles	24	30
Food waste	15	38
Wood	43	50
Garden and Park waste	20	49
Nappies	24	60

Source: IPCC Guidelines, Vol. 5, Chapter 2, Table 2.5

With a first order reaction, the amount of product is always proportional to the amount of reactive material. This means that the year in which the waste material was deposited in the disposal site is irrelevant to the amount of CH_4 generated each year. It is only the total mass of decomposing material currently in the site that matters.

DDOCm ACCUMULATED IN THE SWDS AT THE END OF YEAR T

$DDOCma_T = DDOCmd_T + (DDOCma_{T-1} X e^{-k})$

DDOCm DECOMPOSED AT THE END OF YEAR T

$DDOCmdecomp_T = DDOCmaT - 1 x (1 - e-k)$

Where,

T = inventory year

$DDOCma_T$ = DDOCm accumulated in the SWDS at the end of year T, Gg

$DDOCma_{T-1}$ = DDOCm accumulated in the SWDS at the end of year (T-1), Gg

$DDOCmd_T$ = DDOCm deposited into the SWDS in year T, Gg

$DDOCm,decomp_T$ = DDOCm decomposed in the SWDS in year T, Gg

k = reaction constant,

k = $\ln(2)/t1_{/2}$ (y-1) = 0.17 (IPCC)

$t_{1/2}$ = half-life time (y) (IPCC)

8.5. Wastewater Treatment and Discharge

1.4 D1 Domestic Wastewater Treatment and Discharge

A. Category Description

Domestic wastewater includes human sewage mixed with other household wastewater, which can include effluent from shower drains, sink drains, washing machines, etc. This source category refers to CH_4 and N_2O emissions generated due to the treatment and discharge of domestic wastewater. CH_4 emissions are generated from domestic wastewater on its treatment (on site through septic tanks, connected by sewer network to a centralized treatment plant) or untreated disposal via an outfall under anaerobic conditions (IPCC, 2019). The extent of CH_4 emission from wastewater depends primarily on the quantity of degradable organic material in the wastewater, the volume of wastewater generated, and the type of treatment system used

B. Methodology

Table 19: Type of Emission Factor and Level of Methodological Tier adopted for Domestic Wastewater Treatment and Discharge State-level Estimates

IPCC ID	GHG source & sink categories	CH_4		N_2O	
		Method Applied	Emission Factor	Method Applied	Emission Factor
4D1	Domestic wastewater treatment and discharge	T1	D	T1	D

Notes: T1: Tier 1; CS: Country-specific; D: IPCC default

CH_4 Emissions from Domestic Wastewater Treatment and Discharge

Calculation of CH_4 emission from treatment of domestic wastewater is largely based on the city population and the degree of utilization of the treatment system or discharge pathways relevant to urban residents. The total organics in wastewater determine the quantum of CH_4 emissions.

As per the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, the following equation is used to estimate CH_4 emissions from domestic wastewater treatment and discharge.

$$CH_4Emissions = \sum_{i,j}[(U_i \times T_i \times EF_j)](TOW - S) - R$$

Where,

CH_4 Emissions = Methane emissions in inventory year, kg CH_4/yr

TOW = total organics in wastewater in inventory year, kg BOD/yr

S = organic component removed as sludge in inventory year, kg BOD/yr (default value of 0) (IPCC)[57]

U_i = fraction of population in income group i in inventory year

$T_{i,j}$ = degree of utilization of treatment/discharge pathway or system, j, for each income group Fraction i in inventory year

i = income group: rural, urban residents for the respective state

j = each treatment/discharge pathway or system

EF_j = emission factor, kg CH_4 / kg BOD

R = amount of CH_4 recovered in inventory year, kg CH_4/yr (default value of 0) (IPCC)[58]

The emission factor EF_j is applicable for the various type treatment systems or discharge pathways based on the corresponding MCF as per IPCC (Table C3). It is a function of the maximum CH_4 producing potential (B_o) and the methane correction factor (MCF) for the wastewater treatment and discharge system (IPCC, 2019)[59]. The MCF indicates the extent to which the CH_4 producing capacity (B_o) is realized in each type of treatment and discharge pathway and system.

CH_4 Emission Factor $EF_j = B_O \times MCF_j$

Where,

EF_j = emission factor, kg CH_4/kg BOD

j = each treatment/discharge pathway or system

B_o = maximum CH_4 producing capacity, kg CH_4/kg BOD (Default value 0.6) (IPCC)

MCF_j = methane correction factor (fraction)

The default MCF values for different types of domestic wastewater treatment and discharge pathways as available in the IPCC guidelines.

Table 20: Default MCF values by treatment type and discharge pathway

Type of treatment and discharge pathway or system	Description	MCF
Untreated system		
Sea, river and lake discharge	Rivers with high organic loadings can turn anaerobic	0.1
Stagnant sewer	Open and warm	0.5
Flowing sewer (open or closed)	Fast moving, clean. (Insignificant amounts of CH_4 from pump stations, etc.)	0
Treated system		
Centralized, aerobic treatment plant	Must be well managed. Some CH_4 can be emitted from settling basins and other pockets.	0
Centralized, aerobic treatment plant	Not well managed. Overloaded.	0.3
Anaerobic digester for sludge	CH_4 recovery is not considered here.	0.8
Anaerobic reactor	CH_4 recovery is not considered here.	0.8
Anaerobic shallow lagoon	Depth less than 2 meters, use expert judgment	0.2
Anaerobic deep lagoon	Depth more than 2 meters	0.8
Septic system	Half of BOD settles in anaerobic tank	0.5
Latrine	Dry climate, ground water table lower than latrine, small family (3-5 persons)	0.1
Latrine	Dry climate, ground water table lower than latrine, communal (many users)	0.5
Latrine	Wet climate/flush water use, ground water table higher than latrine	0.7
Latrine	Regular sediment removal for fertilizer	0.1

Source: IPCC Guidelines, Vol. 5, Chapter 6; Table 6.3

A key parameter for this source category is the total amount of organically degradable material in the wastewater (TOW). This parameter is a function of human population and Biochemical Oxygen Demand (BOD)[61] content of wastewater generated per person. It is expressed in terms of biochemical oxygen demand (kg BOD/year).

The equation for TOW in domestic wastewater is

$$TOW = P * BOX * 0.001 * I * 365$$

Where,

TOW = total organics in wastewater in inventory year, kg BOD/yr

P = population in inventory year, (person)

BOD = state-specific per capita BOD in inventory year, g/person/day,

0.001 = conversion from grams BOD to kg BOD

I = correction factor for additional industrial BOD discharged into sewers

8.6. Ward-level Vulnerability Methodology

Methodology of calculating vulnerability indices : An aggregate composite score with equal weights of all four dimensions (NVI, SVI, EVI, PVI) are estimated to gather the information of composite vulnerability indices of the wards. The high CVI indices shows wards most vulnerable to hazards. The indicators for the assessment of each four dimension are in terms of exposure, sensitivity and adaptive capacity.

The indexing framework assumes that all the indicators are equally important for inducing vulnerability of the wards in the city. During the aggregation phase these indicators were normalized and added to obtain the arithmetic mean. Data ranges and scales used will be different among the indicators and in order to compare and perform arithmetical operations on them, they would be normalized (Gómez-Limón & Sanchez-Fernandez, 2010) during their integration into aggregate vulnerability index within a dimensionless range (0–1).

All the exposure and sensitive indicators are normalized with the formula/equation 1 :

$$Zi = \frac{Xi - Xmin}{Xmax - Xmin} \tag{1}$$

Zi = Normalised value

Xi = Actual Value

Xmin = Minimum value of total values

Xmax = Maximum value of total values

And all the adaptive capacity indicators parameters are normalized with the below formula, which is actually inversely proportional to vulnerability :

$$Zi = \frac{Xmax - Xi}{Xmax - Xmin} \tag{2}$$

Exposure indicators : Exposure indicators / maps derived from the flood modelling wherein the extend of flooding is considered for flood exposure. The Exposure index is calculated using following algorithm.

$$Ei = \frac{\sum Xie}{\sum Xi \sum Xie} \tag{3}$$

where Ei refers to exposure index, ∑ Xi = sum of variables of exposure indicators; ∑Xie = total number of variables.

Sensitivity indicators : Sensitivity concerns with the extent to which the wards are affected by hazards. Sensitivity reflects the degree of tolerance in a social structure, population attributes, SC/ST, work force participation, poor roof. material Sensitivity index executed by :

$$Si = \frac{\sum Xis}{\sum Xi \sum Xis} \tag{4}$$

where Si refers to Sensitivity index; ∑ Xi = sum of variables of Sensitivity indicators; ∑Xis = total number of variables.

Adaptive Indicators : Adaptation has been used as nature and human adjustment to climate induced changes. It corresponds to the potentiality of people to adapt exposed event. The indicators include- drainage network, literacy, access to information etc. The adaptation index formula:

$$Ai = \frac{\sum Xia}{\sum Xi \sum Xia} \tag{5}$$

where Ai refers to Adaptive index, ∑Xi= sum of variables of Adaptive indicators; ∑Xia = total number of variables.

Vulnerability Index : The Vulnerability index for each of the four dimensions in this study is determined as the positive function of Ei and Si, but negative function of Ai following Li et al. (2015), as under :

$$Vulnearbility\ Index = \frac{Ei * Si}{Ai} \tag{6}$$

For each of the four dimensions (Natural, Physical, Social and Economic) of vulnerabilities the Vulnerability indexes are calculated known as NVI (Natural Vulnerability Index), SVI (Social Vulnerability Index), EVI (Economic Vulnerability Index), PVI (Physical Vulnerability Index).

Composite Vulnerability Index (CVI) : It is the combination of NVI, SVI, EVI and PVI indices, where we have allotted equal weights for the CVI calculations.

8.7. Composite vulnerability indices

Table 21: Composite Vulnerability Index – Jammu

Wards	NVI	SVI	EVI	PVI	CVI
1	0.62	0.38	0.61	1.00	0.65
2	0.50	0.91	0.52	1.00	0.74
3	0.86	0.79	0.74	0.45	0.71
4	0.10	0.16	0.16	0.05	0.11
5	0.70	0.77	0.52	0.11	0.52
6	0.92	0.72	1.00	0.28	0.73
7	0.85	1.00	0.87	0.53	0.81
8	0.80	0.68	0.79	0.71	0.74
9	0.44	0.20	0.48	0.07	0.30
10	0.60	0.48	1.00	0.37	0.61
11	0.59	0.54	1.00	0.65	0.70
12	0.87	1.00	1.00	0.13	0.75
13	0.01	0.02	0.01	0.00	0.01
14	1.00	0.36	1.00	0.45	0.70
15	0.81	0.40	1.00	1.00	0.80
16	0.49	0.75	0.47	0.26	0.49
17	0.30	0.26	0.34	0.08	0.24
18	1.00	0.45	1.00	0.04	0.62
19	0.94	0.43	0.85	0.27	0.62
20	0.80	0.38	1.00	0.20	0.59
21	0.88	0.28	1.00	0.01	0.54
22	0.90	0.37	1.00	0.21	0.62
23	0.91	1.00	1.00	0.30	0.80
24	1.00	0.41	1.00	1.00	0.85
25	0.85	0.41	1.00	0.00	0.56
26	1.00	0.54	1.00	0.15	0.67

Wards	NVI	SVI	EVI	PVI	CVI
27	1.00	0.52	1.00	0.30	0.71
28	1.00	0.66	1.00	0.06	0.68
29	1.00	1.07	1.00	0.29	0.84
30	1.00	0.46	1.00	0.31	0.69
31	1.00	0.56	1.00	1.00	0.89
32	1.00	0.60	1.00	0.30	0.73
33	1.00	0.46	1.00	1.00	0.86
34	0.66	1.00	0.67	0.22	0.63
35	0.65	0.21	1.00	0.49	0.59
36	0.36	0.26	0.39	0.06	0.27
37	0.33	0.22	0.24	0.02	0.20
38	0.87	0.22	1.00	0.10	0.55
39	1.00	0.36	0.98	1.00	0.84
40	0.99	0.84	1.00	0.32	0.79
41	0.94	0.56	1.00	0.18	0.67
42	0.86	0.70	1.00	0.05	0.65
43	0.88	1.00	1.00	0.15	0.76
44	0.81	0.66	1.00	0.06	0.63
45	0.91	1.00	1.00	0.18	0.77
46	0.90	0.49	1.00	1.00	0.85
47	0.41	0.39	0.41	0.62	0.46
48	0.70	0.26	0.63	1.00	0.65
49	0.51	0.20	0.37	1.00	0.52
50	0.53	0.07	0.94	0.17	0.43
51	0.55	0.45	0.91	1.00	0.73
52	0.77	0.14	0.79	1.00	0.68
53	0.80	0.17	1.00	0.35	0.58

Wards	NVI	SVI	EVI	PVI	CVI
54	0.77	0.12	1.00	0.28	0.54
55	0.77	0.25	0.50	0.59	0.53
56	0.93	0.57	1.00	0.58	0.77
57	0.86	0.54	0.78	0.69	0.72
58	0.94	0.76	1.00	0.08	0.70
59	1.00	0.83	1.00	0.09	0.73
60	0.44	0.48	0.89	0.51	0.58
61	0.94	0.78	1.00	0.26	0.75
62	0.28	0.07	0.45	0.22	0.26
63	0.37	0.23	0.74	0.20	0.38
64	0.54	0.26	1.00	0.16	0.49
65	0.77	0.23	1.00	0.26	0.57
66	0.68	0.78	0.27	0.84	0.64
67	0.96	0.55	1.00	0.05	0.64
68	0.77	0.28	0.01	0.09	0.28
69	0.50	0.06	1.00	0.26	0.46
70	0.54	0.13	1.00	0.02	0.42
71	0.55	0.20	0.29	0.44	0.37

Vulnerability Index values: Low range- 0 to 0.33 (Green); Medium range (> 0.33 to 0.66) (Blue); High value range (>0.66 to 1) (Orange)

8.8 Livestock Population

(in lacs)

Year	Cross Breed Cattle				Indigenious Cattle				Buffaloes				Pigs	Horses & Ponies	Poultry
	Dairy	Non-Dairy			Dairy	Non Dairy			Dairy	Non Dairy					
		<1yr	1-3yr	Adult		<1 Yr	1-3 yr	Adult		<1 Yr	1-3 yr	Adult			
2003	0.9814	0.0918	0.11216	0.2103	1.512693	0.64635544	0.37797554	0.4668733	1.5169	0.15169	0.17336	0.32505	165	9	1.956
2004	1.03047	0.09639	0.117768	0.220815	1.6011274	0.59298664	0.3405185	0.44333347	1.592745	0.159275	0.182028	0.341303	188	8	2.0069
2005	1.051079	0.93636	0.114403	0.214506	1.3739907	0.54402444	0.30677342	1.18074208	1.6246	0.154724	0.176827	0.331551	147	5	2.204
2006	1.06159	0.092718	0.114403	0.212403	1.241184	0.49910499	0.27637245	0.39233051	1.640846	0.153207	0.175094	0.328301	151	4	2.1983
2007	1.082822	0.93636	0.113282	0.216506	1.2842376	0.45789449	0.24898419	0.37254914	0.418	0.154724	0.176827	0.331551	136	6	2.0065
2008	0.4975	0.11216	0.114403	0.1402	1.1240473	0.42008669	0.22431008	0.99222024	0.4389	0.106183	0.121352	0.15169	184	8	2.0005
2009	0.522375	0.117768	0.0918	14721	1.383403	0.38540063	0.20208116	0.3296895	0.452067	0.111494	0.12742	0.159275	169	7	1.9987
2010	0.538046	0.115525	0.09639	0.144406	1.357545	0.35357856	0.1820551	0.3130665	0.461108	0.109368	0.124993	0.156241	121	9	2.0068
2011	0.548807	0.114403	0.094554	0.143004	1.305829	0.324384	0.1640136	0.83379852	0.45404	0.108307	0.123779	0.154724	178	4	1.9598
2012	0.36906	0.25834	0.093636	0.55359	1.2929	0.2976	0.14776	0.27705	0.484	0.317828	0.363232	0.681026	135	3	0.3888
2013	0.624	0.04369	0.295248	0.0936	1.241184	0.60757411	0.1418496	0.243804	0.466	0.03388	0.03872	0.0726	191	9	1.9506
2014	0.552	0.03864	0.04992	0.0828	1.1170656	0.54940212	0.1300288	0.1967055	0.4666	0.3262	0.03782	0.06999	164	8	1.9605
2015	0.602	0.0428	0.04416	0.099	1.03432	0.48896789	0.1344616	0.1911645	0.453	0.3262	0.03624	0.0699	151	4	2.304
2016	0.555	0.03885	0.0488	0.08325	0.995533	0.53001146	0.1137752	0.1412955	0.488	0.03171	0.03624	0.06795	164	7	2.352
2017	0.587	0.04109	0.0444	0.08805	0.892101	0.46641009	0.081268	0.1246725	0.698	0.034209	0.039096	0.073305	196	6	2.435

Mobile Officer
Mobile Clinical Unit-I
Animal Husbandry Deptt
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